SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1924.

GENERAL PHYSICS.

1645. *Annual Report of the International Time Service for* 1923. **G. Bigourdan.** (Bull. Astronomique, 3. No. 3. pp. 361–392, 1923.)—A detailed account of the time signals sent out from Lyons, Bordeaux, and Paris (Eiffel Tower), and of the behaviour and regulating of the clocks used for determining the time. M. A. E.

1646. *The Time Service of the Paris Observatory.* **G. Bigourdan.** (Bull. Astronomique, 3. No. 2. pp. 265–329, 1923.)—[See Abstract 1017 (1923).]

1647. *The Interrelations of Modern Physics and Modern Psychology.* **L. T. Troland.** (Frank. Inst., J. 197. pp. 479–504, April, 1924.)

1648. *Density and Viscosity of Acetone at Low Temperatures.* **E. H. Archibald and W. Ure.** (Chem. Soc., J. 125. pp. 726–731, March, 1924.) —Acetone has the following densities at various temperatures: 0°, 0·8140; −10°, 0·8251; −20°, 0·8370; −30°, 0·8473; −40°, 0·8575; −50°, 0·8777; −70°, 0·8884; −80°, 0·9002; and −90°, 0·9117. The values of the viscosity in absolute units are: 0°, 0·00389; −10·6°, 0·00451; −20·4°, 0·00517; −30·3°, 0·00613; −40°, 0·00713; −49·9°, 0·00818; −59·7°, 0·00981; −69·7°, 0·01200; −79·7°, 0·01505; and −89·7°, 0·02051. The increase in the viscosity per degree is doubled with change of temperature from −25° to −85°, this variation possibly accounting to some extent for the high-temperature coefficients of conductivity found for solutions of organic substances in the liquid halogen hydrides. T. H. P.

1649. *The Densities and Specific Volumes of Sodium Chloride Solutions at* 25°. **R. E. Hall.** (Washington Acad. Sci., J. 14. pp. 167–173, April 19, 1924.)—The densities and specific volumes of sodium chloride solutions at 25° C. and at concentrations up to 25·5 per cent. are presented. They have been determined with an accuracy of 5 parts per million.

1650. *Density and Diffusion of Gases Measured by Displacement Interferometry.* **C. Barus.** (Nat. Acad. Sci., Proc. 10. pp. 153–155, April, 1924.)—The pressure due to a column of gas (*e.g.* coal gas), 68 cm. long, is compared by means of the interferometer **U**-gauge [see Abstract 1 (1922)] with that due to an identical column of air. The progress of diffusion at the ends of the gas column is measured by observing the displacement of the interference fringes at regular intervals of time. J. S. G. T.

1651. *Matters of Special Interest in Precision Metrology.* **A. Pérard.** (Rev. d'Optique, 2. pp. 506–511, Dec., 1923.)—It is desirable that a precise definition should be given of the exact method of making a setting with a microscope on a line graduation. This definition might be, " to set the microscope so as to obtain equality of the luminous areas between the lines of the microscope graticule and the edges of the line upon which the setting is made." There is a personal error in making this setting, due to the right and left asymmetry of the observer's eye. This error may be eliminated by taking two sets of observations in such positions that the right and left of the eye are reversed with respect to the microscope. To eliminate the fogging of microscope objectives, especially with heated bars, the mounting of the objective may be surrounded with small coils of electrically heated wire, so that the temperature is raised several degrees. To avoid torsional forces on bars, these may be furnished at their points of support with circular mountings having their centres on the neutral axis of the bar, which then rests freely on a horizontal plane. J. W. T. W.

1652. *Surface Tension Measurements in a Magnetic Field.* **Winifred L. Rolton** and **R. S. Troop.** (Phys. Soc., Proc. 36. pp. 205–207; Disc., 207–209, April, 1924.)—Using the method of measuring surface tensions for small quantities of liquids recently described by A. Ferguson [Abstract 728 (1924)] tests have been made of the effect of a magnetic field on the surface tensions of solutions of ferric and manganese chlorides. With a field of 16,000 Gausses no effect is observed, indicating no change as great as 4 in 10,000. In the *discussion* **D. Owen** points out that from energy consideration no observable effect is to be expected. G. A. S.

1653. *The Measurement of High Vacua.* **H. Stintzing.** (Zeits. Phys. Chem. 108. pp. 70–81, Jan., 1924.)—A method is developed for the measurement of low pressures, which is based on the observation of the luminous appearance when the gas, which is contained in a narrow tube, is submitted to the discharge from an induction coil. The range of pressures as measured by the McLeod gauge, over which the discharge is observed, is from 10 mm. to 10^{-5} mm. The characteristic discharges obtained at different pressures are noted. The method is less definite than that of a compression method, as in the McLeod gauge, but it is more rapid and is applicable to lower pressures.

A system is described in which both the above principles are applied. The gas from a reservoir of 0·1 to 10 litres capacity is compressed into a capillary of 0·1 c.c. volume, through which aluminium electrodes attached to platinum wires are sealed. The rarified gas is compressed into the calibrated capillary tube until one or other of the characteristic discharges is obtained when the volume is estimated from the height of mercury in the capillary, and the pressure is obtained from the difference of height of the mercury column in the measuring tube and that in a vertical tube alongside. Pressures as low as 10^{-10} mm. are thus measured. The influence of the mercury vapour on the type of discharge is minimised by lowering the temperature of the mercury in the reservoir from which the compression is effected. This cooling is brought about by surrounding the reservoir with a vessel in which ether is evaporated. J. N. P.

1654. *Measuring Compressibility of Solids by an Interferometer Method.* **H. C. Bates.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 93–101, 1923.)—Experiments are described in which the compressibility of solids is measured by a new method over a range of pressure up to 200 atmospheres, and some results are given of measurements on crystals of fluorite cut in different directions, on quartz, brass, and on a crystal of tourmaline parallel to the crystal axis. The method can be used with quite small crystals, and is claimed to be subject to fewer errors and corrections than those of other investigators. Temperature effects receive special attention.

The compressibilities found are all smaller than those determined by others, but are of the same order of magnitude. Fluorite shows marked differences between the compressibility in the different directions. In the case of fluorite and brass compressibility decreases with increasing pressure over the range dealt with, but the quartz and tourmaline show the opposite effect. The pressure variation for quartz is said to be larger than for fluorite. M. A. G.

1655. *Viscosities of Binary Mixtures of Sulphuric Acid, Potassium and Sodium Hydroxides.* **L. J. Simon.** (Comptes Rendus, 178. pp. 1076–1079, March 24, 1924.)—The results of measurements of the viscosity of solutions containing acid and alkali in varying proportions, but in constant total molecular concentration show that the minimum values correspond, in the case of sodium hydroxide, with the formation of $NaHSO_4$, and in the case of potassium or rubidium hydroxide with that of K_2SO_4 or Rb_2SO_4. With mixtures of sodium and potassium hydroxides the viscosities are rather lower than those calculated according to the straight line law.

T. H. P.

1656. *Direct Reading and Recording Pyrheliometer.* **L. Gorczynski.** (Comptes Rendus, 178. pp. 1200–1201, March 31, 1924.)—A Moll theomopile of 80 manganin-constantan elements with a 2 cm. diameter face gives an e.m.f. of 90 microvolts per metre-candle, and hence can be used as a direct reading or recording pyrheliometer with a millivoltmeter. The lag of such a couple is not more than two seconds. If mounted on an equatorial mounting, a continuous record of the solar radiation can be obtained.

A. Wh.

1657. *Silvering of Glass by the Formol Process.* **A. Cotton.** (Rev. d'Optique, 3. pp. 57–64, Feb., 1924.)—Full directions are given for the preparation of the glass and bath and for carrying out the silvering by the formol process, which may be used for mirrors up to 20 cm. in diameter and gives a deposit about 50 $\mu\mu$ in thickness. T. H. P.

1658. *Vacuum Sealing with Wood's Metal.* **L. A. Welo.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 453–454, March, 1924.)—Wood's metal is found to " take " very readily on to glass surfaces without the use of any flux, and adheres so well as to prevent the passage of gas along the interface. It can thus be used as a general substitute for wax or cement for closing joints of different kinds. G. A. S.

1659. *Effects Produced by Chilling Glass.* **A. Q. Tool** and **C. G. Eichlin.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 419–449, March, 1924.)—Data were obtained for several glasses, but principally from a borosilicate crown, used in the most extended series of experiments, as the results appeared in most respects representative. The glass and its preparation, the apparatus for the detection of thermal effects, and the method of packing are given. The curves for showing the differences in temperature between the glass and the neutral body during heating were obtained by plotting the deflections of a galvanometer (in series with the differential thermocouple) or the actual differences in temperature represented by them as ordinates, and the corresponding temperatures of the glass as abscissæ. A graphic method for analysing and comparing the differences between the curves of chilled and annealed glasses and for locating the approximate temperatures at which the critical stage begins and ends is illustrated and described. Changes in the form of the heating curves by varying the chilling temperature and the annealing periods, and the changes of volume caused by chilling and annealing are set forth very fully. The results of the many experiments would seem to show that: (1) cooling glass slowly through the annealing range allows some molecular readjustment, which may include the formation of large molecules or aggregates, while cooling it rapidly prevents such readjustments; (2) such readjustments appear to change such characteristics of the glass as its density, refractive index, homogeneity, stability, etc.; (3) heating glass for long periods at a given temperature allows it to come to a condition of equilibrium which, over a wide range, varies with the treating temperature. T. C. H.

1660. *Acoustic Method of Depth-Sounding for Navigational Purposes.* By the **Staff of the Director of Scientific Research, Admiralty.** (Nature, 113. pp. 463–465, March 29, 1924.)—A brief summary of the methods of sounding at sea is given from the earliest times to the present day. For more than 2000 years the simple method of the "lead" was employed without modification—*i.e.* until the invention of the Kelvin sounding-machine. During the last few years, however, subsequent to the development of the hydrophone (or under-water telephone), methods based on the reception of an acoustic echo from the sea-bed have been devised in the U.S.A., France, Germany, and in this country. In all these methods a sound source transmits acoustic vibrations to the water, and the reflected sound from the sea-bed is received by means of a hydrophone. The methods differ in the means of determining the depth. In the German method the depth is estimated by measuring the intensity of the echo. Obviously this will be unsatisfactory in practice, for sea-bottoms of mud or of rock will have different coefficients of reflection. In one of the American methods the depth is estimated from measurements of the angle between the transmitted beam and the reflected beam. This method has given good results, but elaborate corrections are necessary when the sea-bed is not horizontal. In the French system a detonator is fired near the ship, and the time interval measured between the instant of firing and the arrival of the echo. The apparatus has been made automatic and selfindicating, but has the disadvantage that a large supply of detonators is required to take a line of soundings over a considerable distance.

In Great Britain attention has been paid chiefly to the development of a system depending on the measurement of the time interval, and a robust apparatus based on this principle has been designed and constructed by the Research Department of the Admiralty. In this apparatus the source of sound is a steel diaphragm set in vibration at regular intervals by a spring hammer controlled by an electromagnet. The receiving hydrophone is a simple microphone enclosed in a rubber body immersed in the water. A small motor, of constant speed, drives two switches, one of which operates the magnetic hammer of the diaphragm transmitter, and the other short-circuits the telephones in the receiving circuit except for small fraction of the revolution as determined by a small insulated segment. When, therefore, the apparatus is running, no sound is heard unless the insulating segment in the telephone switch happens to open the telephone circuit at the instant when the transmitter is actuated or at the instant when the echo returns from the sea-bottom. By a simple mechanism the position of the insulating segment in the telephone circuit can be displaced by hand relative to the corresponding pair of brushes, so that an interval of time proportional to the angular displacement of the brushes intervenes between the emission of an impulse by the transmitter and the opening of the telephone circuit. Hence the angular displacement gives a measure, in terms of the known speed of rotation of the switch, of the time taken for the sound to travel from the transmitter to the receiver—a distance approximately double the depth of the water. The apparatus has been tried at sea and has given very satisfactory results. For actual data the original paper should be consulted. A. B. W.

1661. *The Phonic Chronometer.* **A. B. Wood** and **J. M. Ford.** (Journ. Sci. Instruments, 1. pp. 161–173, March, 1924.)—A tuning-fork of adjustable frequency controls the speed of a small electric motor, the combination forming a phonic motor; a light dial wheel can be put into gear with the flywheel of the motor and thrown out as required by means of an electromagnet, being brought to rest very quickly in the latter case by means of an adjustable brake; toothed dial wheels were used in some instruments, but a friction drive has proved quite satisfactory; it is possible to balance the starting and stopping errors, so that the total error due to all causes is considerably less than 0·001 second. The gear ratio can be adjusted for by altering the position of weights attached to the ends of the tuning-fork, so as to make the dial readings correct; slip error is negligible. Chronometers have been constructed with three sets of dials, driven by a common motor, with which three time intervals can be measured simultaneously or in rapid succession. A new type of tuning-fork contact is described, which gives constant contact pressure and constant vibration frequency; temperature variations of the tuning-fork were not found important for comparatively short time intervals; for long intervals Dye's fork, constructed of "Elinvar" steel, could be used. The time-constant of the electromagnet should be small; this can be arranged by putting a large non-inductive resistance in series with it (a metal filament lamp of about 1500 ohms) and using a high voltage to get the necessary current. A double-break method of operation was adopted for the two operations of starting and stopping, so that the times taken should be the same; there were two differential windings, and with equal currents the armature was not affected. Breaking one current brought the dial wheel into contact with the revolving flywheel; breaking the second current brought the dial wheel back against the brake. Methods of eliminating and compensating other errors are dealt with, and accuracy tests are described. The instrument has been used to determine variation of period of a pendulum with amplitude of swing, velocity of sound in the sea, psychological measurements, motor-car speeds, electrical quantity (current × time). H. N. A.

1662. *Atomistic Structure of Deformed Crystals in Relation to Processes of Solidification.* **R. Gross.** (Zeits. f. Metallkunde, 16. pp. 18–23, Jan., 1924.)—A summary is given of previous crystallographic observations on crystals deformed by simple shearing, translation, or stratification, and experiments on the elastic and plastic bending of plates of rock salt and mica are described, which indicate the complete analogy of these plates with metallic crystals. Structure schemes for the two types of bending, based on the results obtained, are explained. T. H. P.

1663. *Auxiliary Apparatus for Use in Experiments with Gases and Vacua.* **E. Brüche.** (Zeits. techn. Physik, 5. 4. pp. 141–143, 1924.)—Two pieces of apparatus, the one for delivering gas into a vacuum and the other for transferring gas at atmospheric pressure from one vessel to another, are described. J. S. G. T.

1664. *The Structure and Disintegration of Liquid Films.* **W. Taylor.** (Ann. de Physique, 1. Ser. 10. pp. 134–170, Jan.–Feb., 1924.)—By equating the loss of potential energy when *n* spheres coalesce into a single sphere to the latent heat of condensation a value of Avogadro's number is obtained agreeing well with other determinations—*i.e.*, the molecules seem to behave as spheres possessing surface energy and surface tension—and this led the author to treat molecular problems from such a standpoint. Proving mathematically that long cylinders or large laminæ have their total surface energy reduced when they disintegrate into a number of spheres, the author was led to expect such a mode of disintegration. When a small drop of oil was placed on a water surface, lightly dusted with powdered talc, the oil was violently detached from the fibre carrying it, the water surface showed a violent tremor, and the talc was brushed away as by a violent wind. Microscopic observation showed the surface to be covered with numerous distinct lenticular drops of oil, all approximately equal, and distributed in a hexagonal lattice. The breakdown of films also showed this aggregation into distinct drops, with hexagonal spacing, but no evidence of anything in the nature of a momo-molecular layer was observed. The various phenomena are described in detail, and sketches illustrating the stages are given.

M. Brillouin (*ibid.*, pp. 171–172) points out that the calculation of Avogadro's number above was made by A. Dupré in 1867. He notes that the maximum length of stable cylinder obtained by Wilson's method is not the same as that obtained by Plateau. This is another instance of difference between stability for infinitesimal and for finite disturbances.

W. G. B.

1665. *Simple Rigidity of a Drawn Tungsten Wire at Incandescent Temperatures.* **W. Schriever.** (Phys. Rev. 23. pp. 255–265, Feb., 1924.)—The diameter of wire studied is 10 mils., and measurements are taken up to 2000° K. Errors due to end effects are avoided by mounting in series and heating by the same current two lengths of the same wire so that the middle portions of both are at the same temperature. At the higher temperatures even a twist of 0·1° per cm. exceeds the elastic limit. On three successive runs made, the rigidity increased progressively, due to crystal growth in the temperature range above 1600° K. For the recrystallised or equiaxed wire the values of the modulus obtained on the third run are, in dynes/cm.^{2}, at 300° K., $21 \cdot 7 \times 10^{11}$; at 1030° K., $21 \cdot 0 \times 10^{11}$; and at 1985° K., $3 \cdot 4 \times 10^{11}$. A. B. C. L.

1666. *Internal Friction Theory of Shaft Whirling.* **A. L. Kimball.** (Gen. El. Rev. 27. pp. 244–251, April, 1924.)—The idea of forces, viscous in nature, resisting the *change* of elastic distortions, is applied to explain the phenomena in whirling shafts. In the case of a flywheel on a horizontal shaft between two bearings, the result of such forces is to deflect the flywheel sideways. Forming and solving the differential equations, including terms representing the action of such forces, it is found that the displacement grows or decays according as the speed is above or below the whirling speed found by the older methods. A model, in which a central thin steel shaft surrounded by copper wires embedded in a viscous material and with such a flywheel that the critical speed was low enough to be seen, bore out these conclusions, and also that the speed of the whirl was the critical speed, and not that of the shaft. W. G. B.

1667. *Researches on Solid Friction.* **G. Sachs.** (Zeits. Math. u. Mechanik, 4. pp. 1–32, Feb., 1924.)—A special testing machine is described by means of which the frictional resistance and amount of slipping between two discs rolling in contact were investigated. Observations of contact pressure, frictional resistance and speed were made. Experiments were carried out with discs of cast-iron, wrought-iron, brass, white-metal, wood and leather in various combinations. The rubbing edges were polished and the effects of wear examined under the microscope. Curves showing the ratio of normal contact pressure and frictional force, *i.e.* the coefficient of friction, are given for a number of different pairs of materials. Characteristic curves of slip plotted against the coefficient of friction are given for a large number of combinations of materials, and it is shown that as the amount of slip increases a condition of stability is approached, accompanied by a maximum value of the coefficient of friction. J. V. H.

1668. *Stresses in a Plate with a Circular Hole.* **S. Timoshenko.** (Frank. Inst., J. 197. pp. 505–516, April, 1924.)—The author deals with the distribution of stress in a plate with a circular hole in which the edge of the hole is reinforced with a bead. S. L. S.

1669. *Compressibility of the Alkali Halides.* **J. C. Slater.** (Phys. Rev. 23. pp. 488–500, April, 1924.)—Measurements have been made on various alkali halides by a method due to Bridgman. The measurements include the compressibility $[k = (\partial v/\partial p)_{\mathrm{T}}/v_0]$; the change of compressibility with pressure $[\psi_0 = (\partial k/\partial p)_{\mathrm{T}}/k_0] = [(\partial^2 v/\partial p^2)_{\mathrm{T}}/k_0 v_0]$, where k_0 is the compressibility under zero pressure; and the change of compressibility with temperature $[(\partial k/\partial \mathrm{T})_p/k_0]$. The measurements were made at 30° and at 75° C., and at pressures up to 12,000 atmospheres. By extrapolation, values of k_0 at absolute zero are also obtained. It is found that when k_0, ψ_0, or the grating space δ_0 are plotted against the alkali ion for a series of salts of the same alkali ion, or *vice versa*, the curves break sharply at the ion (K or Cl) similar to argon. This corroborates Bohr's theory of atomic structure, which assumes a discontinuity in atomic formation at argon, additional electrons going into inner shells.

Information is obtained from the measurements on compressibility and its change with pressure on the question of the energy of the crystal. This will naturally be divided into two parts, the slowly changing attractive energy and the repulsive energy. Evidence is given that the former is due to the electrical forces between the oppositely charged ions, as assumed by Langmuir and others, while the latter, corresponding to what has been roughly termed the "bumping" of the ions, has given rise to various assumptions. Born, for example, gives a formula for the energy, $\phi = -13 \cdot 94e^2/\delta + b/\delta^n$, where the first term is the electrostatic attractive potential, and the second is the repulsive potential. The value for n is 9, except for lithium, where it is 5. The present results show, however, that there is no discontinuity between the properties of lithium and the other metals, and in fact the repulsion between atoms is found not to vary as any single inverse power of the grating space. T. B.

1670. *Priorities, or History of Mathematical Physics.* **E. Hoppe.** (Zeits. f. Physik, 22. 6. pp. 397–400, 1924.)—Leonhard Euler introduced the concepts of vectorial addition ("Mechanik," I, § 19, 1736; "Opera," Ser. II, Vol. I, p. 37) and subtraction ("Theoria Motus," Chap. III, §§ 143 *et seq.*, 1765). This order of thought led him to the calculus of variations. Stevin ("Spartostatica," in "Opera," 1634) had already used the expression "geometrical addition" in reference to the parallelogram of forces. J. Kepler first stated the law of inertia ("Prodromus continens mysterium cosmographicum," 1596; "Astronomia Nova," 1609; "Opera," III, p. 151), applying it to the moon ("Opera," III, p. 313) and planets (*ibid.*, p. 580). J. Kepler also treated gravitation systematically ("Opera," III, pp. 151 *et seq.*). In his "Epitome," p. 522, he calls the force of attraction *vis prensandi*; at p. 534 he states Newton's law correctly; at p. 528 he had blundered it. The principle of moments is not due to Stevin or to Huyghens, but to Hero of Alexandria. Hero also used the parallelogram of motions. Riccioli and Grimaldo were ("Almagestum novum," I, p. 90, 1651) the first to make an energy-measurement of the velocity of a falling body; they let the body fall on one pan of a balance and noted how high the counterpoise was lifted. The deviation of a plumb-line by a mountain occurs first in Newton's posthumous "Treatise of the System of the World," 1728. The equally-tempered scale was not due to Rameau, 1722, or to Werkmeister, 1691, but was strenuously advocated by Michael Stifel ("Arithmetica integra," pp. 78–79, 1544), who also proposed an instrument with 44 tones in the octave. The true founder of the theory of potential (including Laplace's equation) was Leonhard Euler (Brenneke's dissertation). A. D.

1671. *On Quasi-Static Wave Motion in Barotropic Fluid Strata.* **V. Bjerknes.** (Geofysiske Publ. 3. No. 3. pp. 1–24, 1923. In English.)

1672. *Similitude in Hydrodynamics.* **L. Escande** and **M. Ricaud.** (Rev. Gén. d'Él. 15. pp. 723–725, April 26, 1924.)—Experimental deter-

minations of the loss of head in two geometrically similar right-angle bends, with ratio of linear dimensions 6 : 1, under heads in this ratio, give results within 2 % of that required by the laws of dynamical similitude. The pressures at various points were also measured, and the agreement between those of the large and small models, plotted to scale, is extremely good. A right-angled bend of square section-tube having glass walls was used to obtain photographic records of the stream lines, and the dead-water spaces in the angle and on the downstream inner wall are very well marked in the photograph, the latter extending quite halfway across the section.
W. G. B.

1673. *An Explicit Solution of the Problem of Wave Motion in Three Barotropic Fluid Strata.* **L. Högberg.** (Geofysiske Publ. 3. No. 4. pp. 1–11, 1923. In English.)

1674. *A Simple Formal Solution of the General Equations of Elastic Stress.* **R. F. Gwyther.** (Phil. Mag. 47. pp. 965–972, May, 1924.)

1675. *The Theory of Anisotropic Liquids.* **C. W. Oseen.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 18. 4. pp. 1–25, 1924. In German.)—Part I of this paper deals with an investigation of C. Mauguin, who, in 1911, published an account of the liquid-crystalline phase of azoxyphenetole [Bull. Soc. Franç. de Minéralogie. 34. 1911]. Among others, Mauguin investigated the optical properties of a helicoidal structure produced by containing the molten substance between two parallel glass plates, the upper one being rotated through a given angle. The phenomena in parallel light were explained by the simple assumption that the liquid consists of layers, but in convergent light so simple an explanation would not hold, and the present investigation seeks to find whether Oseen's theory of anisotropic liquids can afford the desired solution. The differential equations for the conditions are derived on the assumption that the molecule possesses rotational symmetry about an axis. It is found that between the molecular constants two relations exist which reduce the number of independent constants to three, and the differential equations are then directly integrable, leading to hyper-elliptic integrals. The first result of physical importance is that the pure helicoidal structure assumed by Mauguin is generally incompatible with the differential equations. The angle between the molecular axis and the normal to the plates varies from layer to layer, and a successful qualitative explanation of Mauguin's observations is given for the various cases which arise.

Part II of the paper investigates conical disturbances, such having been described by Lehmann in 1895 for ammonium oleate hydrate, and produced by combining two rod-like crystals in opposite orientations to produce a kind of twinning. Lehmann concluded that the molecules are arranged in rectilinear series, lying upon double cones. The conical disturbances were used by Lehmann to explain the phenomena of flowing crystals. The present author investigates the compatibility of these conical disturbances with his theory for crystalline liquids. For this purpose the requisite differential equation is derived for a molecular arrangement involving only three constants, A, B, C, and for which correspond three exact solutions. The three crystal cases are described by Lehmann—*viz.* the rod-like crystals, a capillary tube containing a solution of ammonium oleate hydrate separating liquid crystals, and in soap bubbles. An investigation of whether a conical disturbance satisfies the differential equation showed that in the vicinity of the twinning plane the equation is approximately satisfied, but that the theory can only explain the rectilinear arrangement of the molecules outside the twinning plane if the constant A is very small compared with C. When the molecules have very elongated form, A and B must be assumed very small with respect to C. From the approximate rectilinear arrangement of the molecules, these must be regarded as very long on the theory. This result stands in better agreement with the results of Vorländer's chemical investigations of substances which give liquid crystals. H. H. Ho.

1676. *The Settling of Small Particles in a Fluid.* **M. Mason** and **W. Weaver.** (Phys. Rev. 23. pp. 412–426, March, 1924.)—Small particles immersed in a liquid experience a motion which is the combination of a steady gravitational drift and a Brownian movement. If there are space variations in the density of distribution of particles, the Brownian movement produces a diffusion which tends to equalise the density. In the steady state the density n of particles is an exponential function of x, the distance below the surface of the liquid. This paper investigates mathematically the manner in which the steady state is established. A consideration of the combined effect of fall and diffusion leads to a partial differential equation for the number density of particles as a function of depth and time. A set of special solutions is obtained in terms of which a solution satisfying initial and boundary conditions can be expressed, *viz.*: (1) For a liquid of finite depth with an arbitrary initial distribution $n_0 = f(x)$ a reduced form of the solution is obtained, when there is uniform initial distribution, which contains a single parameter. This one parameter family of curves is plotted, and from these curves, either directly or by interpolation, the density distribution may be obtained at any time for a solution of any depth, density, and viscosity, and for particles of any size and density. For small values of t, since the solution obtained converges slowly, an image method is used to obtain an integral formula for the density. (2) In the case of a liquid of infinite depth the solution for an arbitrary initial distribution is expressed by the Fourier integral identity. The case of zero initial density for negative x, and constant initial density for positive x, is calculated, as is also the case of particles initially uniformly distributed over a layer of depth h. In the case of a liquid extending from $x = 0$ to $x = \infty$, the boundary conditions are satisfied by assuming a suitable fictitious initial distribution over the range from $x = -\infty$ to $x = 0$. The cases of uniform initial distribution and initial distribution over a layer are calculated. The latter case, while derived for a liquid of semi-infinite depth, gives approximately the distribution of density during the settling of a layer of particles initially distributed uniformly over a depth h at the upper end of a very long column of liquid. H. H. Ho.

1677. *Life of Molecules in Upper Quantum States.* **R. C. Tolman.** (Nat. Acad. Sci., Proc. 10. pp. 85–87, March, 1924.)—In an article to be published in the "Physical Review" a discussion is given of the possibility of calculating from data on the intensity of absorption lines the mean life τ of atoms and molecules in excited quantum states and the chance per unit time that a molecule in quantum state 2 will spontaneously jump to quantum state 1 in the absence of exciting radiation, this quantity being written A_{21}. The expression derived is

$$A_{21} = \frac{8\pi\nu^2}{c^2 N_1}\frac{p_1}{p_2}\int_0^\infty \alpha \, . \, d\nu$$

where ν is the frequency of the radiation emitted, p_1 p_2 the *a priori* probabilities of states 1 and 2, and N_1 and α are obtained from absorbtion measurements, N_1 being the number of molecules per unit volume in the lower state and α the absorbtion coefficient for frequency ν. The integral is across the whole of the absorbtion line. A table is given with values calculated for mercury, sodium, calcium, iodine, HCl and HF, and agreement is found with the few data already available. A. Wh.

1678. *A Periodic Law of Atomic Radii.* **W. P. Davey.** (Phys. Rev. 23. pp. 318–321, March, 1924.)—A periodic relationship is evident if the radii of the 44 elements for which the values have been determined from X-ray crystallographic data are plotted as a function of the number of electrons in the outer shell. Beginning with each rare gas, the curves are similar, the ratios of the ordinates being constant for the following nine or ten elements, as far as the values are known. By making use of the new law, rough predictions are made of the radii of ten other elements whose crystal structures have not yet been experimentally determined. AUTHOR.

1679. *Potential Energies of Some Atomic Models.* **Ida Woodward.** (Phil. Mag. 47. pp. 992–1016, May, 1924.)—Assuming an inverse square law of repulsion between two electrons and an attraction between an electron and a positive charge E of the form $Ee(1/r^2 - c/r^3)$, the potential energy of series of static atomic models is calculated. The number of electrons considered is from 1 to 8, 12, 22 and 27. Several possible arrangements of electrons are considered in the more complex cases. It is found that if the law of force between an electron and a positive charge forming the nucleus of an atom of atomic weight N is written: $F = ne^2/r^2 - Ne^2a/r^3$, then approximately $c = Na/n$. A. Wh.

1680. *Atomic Structure.* **W. F. G. Swann.** (Frank. Inst. J. 197. pp. 293–321, March, 1924.)—A lecture in which are described broadly the lines upon which the nuclear theory of atomic structure has evolved. The apparent artificiality of the rules laid down by Bohr and Sommerfeld is shown to be due only to the unaccustomed quantities which are dealt with, and are no more inherently improbable than the classical physical laws. A. Wh.

1681. *Elastic Constants and Lattice Theory.* **G. Heckmann.** (Zeits. f. Physik, 23. 1–2. pp. 47–68, 1924.)—Works out the details of Born's lattice theory for crystals consisting of ions considered as point centres of force. Mathematical. W. G. B.

1682. *The Structure of Bismuth.* **O. Hassel** and **H. Mark.** (Zeits. f. Physik, 23. 5. pp. 269–277, 1924.)—Rotation diagrams were taken, with single crystals, about the directions [100], [110], [111] and [112], and the identity periods in these directions were measured, using Polányi's layer line relation. The structure and parameter value found by A. Ogg, R. W. James and L. W. McKeehan is confirmed; bismuth crystal being ditrigonal scalenohedrical, the space group being D_{3d}^{5}, $r = 6\cdot57$Å., $\alpha = 87°34'$; the elementary cell is face-centred on all sides, and contains eight bismuth atoms; the parameter, as determined from the intensities, is between 0·022 and 0·035. H. N. A.

1683. *X-Ray Spectra and the Structure of the Atom.* **L. de Broglie** and **A. Dauvillier.** (J. de Physique et le Radium, 5. pp. 1–19, Jan., 1924.)—The paper is a *résumé* of the theoretical and experimental work of the authors and M. de Broglie during the past three years. Bohr's spectral theory is taken as the basis, and the analogy is drawn between optical and X-ray spectra. The original paper should be consulted. [See also Abstract 17 (1923).] A. B. W.

1684. *X-Ray Diffraction Patterns for Crystalline and Liquid Benzene.* **E. D. Eastman.** (Am. Chem. Soc., J. 46. pp. 917–923, April, 1924.)—Measurements of the planar spacings in crystalline benzene are described and the results compared with those of Broomé [see Abstract 1758 (1923)] and of Debye and Scherrer.

Crystals, Å.U.	4·90 (*a*)	2·69 (*a*)	2·00 (*a*)	1·54 (*a*)
	4·83 (*b*)	2·70 (*b*)	2·02 (*b*)	
Liquid, Å.U.	4·97 (*c*)	2·73 (*c*)	2·00 (*c*)	1·50 (*c*)
	4·83 (*b*)			

(*a*) Broomé. (*b*) Eastman. (*c*) Debye and Scherrer.

Comment is made on the interesting coincidence of some of the diffraction maxima found for liquid benzene with those of the crystals. A. B. W.

1685. *The Crystalline Structure of Succinic Acid, Succinic Anhydride and Succinimide.* **Kathleen Yardley.** (Roy. Soc., Proc. 105. pp. 451–467, April 1, 1924.)—By means of an X-ray spectrometer, together with a Coolidge tube of molybdenum or rhodium antikathode, measurements are made of the atomic spacings in all the principal zones of the crystals investigated. By means of the formula: $(abc \sin \beta)\rho = 1\cdot64\, n\mathrm{M}$, where a, b, and c are the axial dimensions in Ångström units, ρ the density of the crystal, and M the molecular weight, it is found that, in the case of the monoclinic holohedral crystal of *succinic acid*, n, the number of molecules per unit cell, has the value 2, and the crystal is based on the Bravais lattice Γ_m. Each of these molecules has a plane of symmetry, and they may be brought into coincidence with each other by a screw of angle 180° and translation $b/2$; thus the space group to which the crystal belongs is C_{2h}^{2}. A probable structure is discussed in detail, an explanation of cleavage and twinning being offered. The orthorhombic crystal of *succinic anhydride* is based on the lattice Γ_0 and has four molecules per cell. It is shown that the X-ray method fails to determine the class to which the crystal belongs. The space group is either C_{2v}' or Q_h', and the molecule is either asymmetric or possesses a plane of symmetry.

In the unit cell of the orthorhombic crystal of *succinimide* there are eight asymmetric molecules, the fundamental lattice being Γ_0. The space group is proved to be Q_h', and details of a probable structure are

given. A comparison of the molecules of succinic acid and of succinimide is made, and the atomic dimensions deduced from the structure are stated.
J. N. P.

1686. *The Crystal Structure of Metallic Arsenic.* **A. J. Bradley.** (Phil. Mag. 47. pp. 657–671, April, 1924.)—The powder photograph method was employed, using a homogeneous beam of K_α copper radiation. Crystals of the type employed are isomorphous with the corresponding crystals of antimony and bismuth. The structure of the two latter consists of two interpenetrating face-centred rhombohedral lattices, related in almost the same way as the Na and Cl lattices in NaCl. These lattices are almost cubic, but slightly elongated parallel to a trigonal axis; one lattice is slightly displaced in a direction parallel to that axis. It was found that, taking into account the relative intensities of the X-ray lines in the photograph, the case of arsenic admits of a similar explanation. The following table gives the results for the three metals, the parameter x being a measure of the displacement of one lattice with regard to the other:—

	As.	Sb.	Bi.
Edge of unit rhomb $2a$	5·60 Å.	6·20 Å.	6·56 Å.
Parameter $2x$	0·097	0·074	0·052
Longer atomic distance.....	3·15 Å.	3·37 Å.	3·47 Å.
Shorter atomic distance ...	2·51 Å.	2·87 Å.	3·11 Å.

Each atom of arsenic, for example, has six nearest neighbours, three at $2{\cdot}51 \times 10^{-8}$ cm., in a plane (111) perpendicular to the trigonal axis, and three in a parallel plane on the other side of the atom, their distances from it being $3{\cdot}15 \times 10^{-8}$ cm. In this way the whole structure is divided into double sets of planes separated by quite wide gaps from the next set. The structure is a special case of Sohnke's point system No. 22 ("Das Zusammengesetzte-Rhomboëdersystem"). This simplifies to a system of point pairs in which each point is at the centre of gravity of three of the original points. H. N. A.

1687. *Atomic Radii and Spectral Terms.* **F. Hund.** (Zeits. f. Physik, 22. 6. pp. 405–415, 1924.)—An attempt to decide between integral or half values for the azimuthal quantum number k for orbits giving rise to the terms of the optical spectra. Erom the transition between hydrogen-like and non-hydrogen-like terms the radius of the atom is calculated, both for whole and half quantum numbers. These values are then compared with those obtained for the radii of ions calculated in other ways. This is done for the alkalies and alkaline earths, and agreement is only obtained for half azimuthal quantum numbers.

If one writes the spectral terms in the form RZ^2/n'^2, where R is Rydberg's number, Z is 1 for the arc spectrum, 2 for the first spark, etc., and n' is the effective quantum number, it will be found that n' is in many cases integral. These are the hydrogen-like orbits, and are supposed to circulate outside the atomic "trunk." The other orbits are those which dive into the atom in each revolution. Thus an upper limit will be the perihelion of the narrowest orbit for which n' is still equal to n, while a lower limit will be given by the widest orbit for which n' is still non-integral. A. C. M.

1688. *The Basis of the Quantum Theory. Part I.* **H. A. Senftleben.** (Zeits. f. Physik, 22. 3. pp. 127–156, 1924.)—In this mathematical paper, which is a contribution towards a complete theory of matter, the methods of the field theories are entirely abandoned and a purely substantial one chosen, in which as basis matter is assumed to consist of a large number of discrete elements which are the energy carriers. These elements are reduced to the units of the electron and the positive nucleus, which constitute the molecular unions. A general principle is then sought for, and the various difficulties arising therefrom are discussed. The occurrence of the Planck constant *h* is the one which stands principally in the way of describing processes by coordinates. It is now found that by diminishing *h* to zero the possibility arises of expressing exactly by coordinates a material process, although limiting cases arise where electrons and nuclei are concerned. The theory of free stable molecules is considered at length and it is found that for a discrete variety of states capable of existence *h* must be replaced by another quantity, h/m, where m is a whole number.

H. H. Ho.

1689. *The Maxwell-Boltzmann Velocity- and Energy-Distribution Law in the Relativity Theory.* **E. Kretschmann.** (Phys. Zeits. 25. pp. 162–165, April 1, 1924.)—The suitable form on the relativity theory for the Maxwell velocity distribution has been derived by Jüttner for the molecule of an ideal gas, as that distribution whose probability is the greatest possible on the basis of the Liouville hypothesis. The author has previously shows [see Abstract 1619 (1920)] that the Liouville hypothesis is by no means so generally valid in the mechanics of the relativity theory as in classical mechanics. The derivation of the velocity- and energy-distribution law in the present paper utilises no probability measure of state, but determines the required distribution as the single points of a force field stationary at the same instant. The effect of the reciprocal forces between the moved masses is admitted, but the forces are assumed independent of the velocity while a potential is to hand. The distribution law is then afforded as in the classical statistical mechanics. An extension of the results so obtained to forces which, on the relativity theory, depend on the velocity, is not possible generally, but is shown to be applicable in the important case of an electro-magnetic force field, this satisfying the Liouville hypothesis. The paper is entirely mathematical.

H. H. Ho.

1690. *On a Non-Symmetrical Affine Field Theory.* **J. A. Schouten.** (K. Akad. Amsterdam, Proc. 26. 9–10. pp. 850–857, 1923.)—In the Eddington-Einstein development of the theory of relativity [Abstract 222 (1924)] the components $\Gamma^{\mu}_{\alpha\beta}$, of the affine field are assumed to be symmetrical in α and β ($\Gamma^{\mu}_{\alpha\beta} = \Gamma^{\mu}_{\beta\alpha}$). Einstein supports this axiom with the remark that both $\partial B_{\mu}/\partial x_{\nu} - \Gamma^{\alpha}_{\mu\nu}B_{\alpha}$ and $\partial B_{\mu}/\partial x_{\nu} - \Gamma^{\alpha}_{\nu\mu}B_{\alpha}$ are tensors, and if they are unequal each seems to have an equal claim to be considered the covariant derivative of B_{μ}, which is therefore not unique. Schouten observes in the present paper that if, by definition, $\delta A^{\mu} = -\Gamma^{\mu}_{\alpha\beta}A^{\beta}\delta x^{\alpha}$, the former of the two above derivatives is distinguished, and preferable, on the ground that it makes the scalar product $A_{\mu}B^{\mu}$ invariant for parallel displacements of A_{μ} and B^{μ}; and he develops the analogue of Einstein's theory when $\Gamma^{\lambda}_{\mu\nu} = \Lambda^{\lambda}_{\mu\nu} + \frac{1}{2}(\delta^{\lambda}_{\nu}S_{\mu} - \delta^{\lambda}_{\mu}S_{\nu})$, $\Lambda^{\lambda}_{\mu\nu}$ being symmetrical in μ and ν, and S_{ν} a certain vector. Taking the same action function as

Einstein, he arrives at field equations of which the symmetrical (gravitational) part is unaltered, but which give for the electromagnetic tensor:

$$f_{ik} = \frac{1}{6}\left(\frac{\partial i_i}{\partial x_k} - \frac{\partial i_k}{\partial x_i}\right) - \left(\frac{\partial S_i}{\partial x_k} - \frac{\partial S_k}{\partial x_i}\right)$$

the last bracket being new. Schouten identifies i_k with the current, S_k with the four-potential, while Einstein identified both current and potentials with multiples of i_k. The asymmetric theory leaves the relation between i and S undetermined, but avoids Einstein's difficulty: that an electromagnetic field can exist only at points where the current-density is not zero.

[The paper contains an extraordinarily large number of misprints in the symbols.] M. H. A. N.

1691. *The Invariance of the Effective Integral and the Form of the Field Equations in the Weyl Theory.* **E. Reichenbächer.** (Zeits. f. Physik, 22. 3. pp. 157–169, 1924.)—This entirely mathematical paper is divided into two parts, the first of which deals with the special character of the invariance of the effective integral. Weyl's work on the relativity theory is first discussed, and the relevant part of a previous investigation by the author on the nature of electromagnetism [see Abstract 1322 (1923)] then extended. The second part investigates the form of the field equations. H. H. Ho.

1692. *On an Hypothesis of the Potential Theory.* **A. Tauber.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 7–8. pp. 309–322, 1924.)—The investigation of the differential quotients of a double-layer potential now described has enabled considerable simplification to be made for the logarithmic potential by the introduction of complex functions which then require no further complex formula apparatus. The further advantage is gained that, apart from the continuity of the cover density, no other assumptions have to be made. In the case of Newtonian potential, simplifications and analogous results are derived. Both curved and plane double layers are considered. The paper is mathematical throughout and should be consulted in its entirety. H. H. Ho.

1693. *The Curvature of de Sitter's Space-time.* **L. Silberstein.** (Roy. Astron. Soc., M.N. 84. pp. 363–366, March, 1924.)—In a previous paper [Abstract 1112 (1924)] was given a method of calculating the curvature radius of space-time from the observed Doppler effect and distance of globular clusters and similar objects. This leads to a value for R, $6 \cdot 0 \,.\, 10^{12}$ astronomical units. It is shown that at comparatively short distances other bodies would exhibit an apparent repulsion. At a certain distance ρ this apparent repulsion would be balanced by the gravitational attraction, and hence it seems likely that at this critical distance from any body there will tend to be a concentration of other bodies. It is shown that this distance, ρ, is connected with the curvature radius of the space-time, R, and the gravitation radius of the mass at the origin, L, by the expression: $(\rho/R)^3 = L/R$. For the sun $\rho = 7 \cdot 1 . 10^5$ astronomical units, corresponding to a parallax 0″·29. Among the 19 nearest stars having parallax > 0″·20, there are 11 which lie between

0″·26 and 0″·33, whereas a uniform distribution would give only 4·4. The effect is not very pronounced, but is advanced in support of the value of R derived from the parallax data. A. Wh.

1694. *Curvature Radius of Space-time.* **L. Silberstein.** (Nature, 113. pp. 602–603, April 26, 1924.)—Two more values for this quantity, as calculated in a recent paper [Abstract 1112 (1924)], are given and a further extension of the method outlined. It is shown that if two spectrograms be taken of a distant object at distance r and radial velocity v_0, the unreduced Doppler effects will be related by the expression :—

$$2v_0(V_2 - V_1) = c^2(D_1^2 - D_2^2) - (V_1^2 - V_2^2)^2$$

where D_1, D_2 are the unreduced Doppler effects at times when the annual and diurnal velocity of the earth is V_1, V_2. This expression will be tested as soon as adequate data are available. A. Wh.

1695. *Relative Motion in connection with Classical Mechanics.* **H. Zanstra.** (Phys. Rev. 23. pp. 528–545, April, 1924.)—While Newton introduced the idea of " absolute " motion, yet he explicitly stated that observed motions are relative. The relative positions of a set of n points are determined by $(3n - 6)$ coordinates, and the author reduces the Newtonian equations of motion for n particles to a set of $(3n - 6)$ differential equations containing the relative coordinates only. Three of these, however, are of the third degree. By introducing Föppl's hypothesis that the moment of momentum of the universe about any axis through its centre of mass is zero, it is possible to reduce the set of equations to a set of $(3n - 6)$, containing the relative coordinates only, and *all of the second degree.* Special forms of the equations, suitable to Ptolemy's and Kepler's systems respectively, are given, in vector notation. Some discussion of previous work and of possible application to Einstein's theory is given. W. G. B.

1696. *Whitehead's Theory of Relativity.* **G. Temple.** (Phys. Soc., Proc. 36. pp. 176–192; Disc., 192–193, April, 1924.)—It has been shown that a generalisation of Whitehead's theory should be on the basis of a space-time manifold of uniform and isotropic curvature. In this paper, which is entirely mathematical, such a generalisation is developed. The physical conclusions drawn are: (1) That the observations on the perihelion of mercury assign a lower limit to the space constant, which is about 10^{16} km.; and (2) that the effect of this curvature on the gravitational deflection of light rays by the sun is negligible. A considerable list of references is appended. A. Wh.

1697. *Uniformity of Time and Testing of Clocks.* **H. Hermann.** (Zeits. f. Physik, 20. 5. pp. 343–344, 1923.)—Prior to the advent of the relativity theory, it was denied that the uniform working of a clock could be established independent of the mechanical laws. Authorities are quoted—*viz.* Neumann, Ducrue, Lodge, Pfaundler, Föppl, Mach. In 1903 Obermayer introduced the innovation of the independence of the pendulum period without resort to mechanical laws, but on the hypothesis of sufficient reasons. The validity of the inertia law has been established on the relativity theory, but not that of time uniformity, and the author now submits what he claims to be a new and simple proof, although he states it to have long been contained in the observation-material of observatories. Two examples of time-measurers, whose equality has been determined by coincidence means, are subjected to further tests by making one precede the other or by establishing definite intervals between them. If independence again occurs, then agreement for every separate period can be concluded. If by uniformity of time be understood the independence of intervals of regulated mechanical processes on the previous ones, then it should be possible to construct uniformly working clocks whose time intervals are independent of mechanics and, in particular, of the inertia law, whereby an empirical determination of the stellar universe can be made. H. H. Ho.

1698. *The Infinity of Space and the General Theory of Relativity.* **F. Selety.** (Ann. d. Physik, 73. 5–6. pp. 291–325, Feb., 1924.)—This comprehensive discussion is divided into four chapters. Chapter I considers Einstein's objections against the infinity of space. It is shown that a Minkowski or quasi-Minkowski world is simpler than a cylinder or quasi-cylindrical world; also that an average density of zero is not improbable, as Einstein held, since it is compatible with complete space content, infinite total mass, and absence of a singular average region. The fulfilment of Einstein's "Mach principle" can be abandoned, especially when the total mass in suitable coordinate systems is non-rotating on the average and is infinite. It is doubtful, also, whether in the finite world, with its actual irregular density, that the Mach principle is satisfied in the sense of determining the G field alone by the $T_{\mu\nu}$. Chapter II discusses the infinity of space for a non-quasi-statical distribution of matter. Reasons are given for the assumption of non-statical matter, irregular quasi-Euclidean space is investigated, and it is shown that in an irregular quasi-Minkowski complex a completely unstatical, mechanically stable, molecular-hierarchical world is possible. The dynamically similar world is found preferable. Chapter III deals first with a centric-symmetrical static model in an irregular quasi-Euclidean space, then with the possibility of summation of the small inertia effects, and finally with the possibility of satisfying the Mach principle for a particular case. Chapter IV summarises the grounds for the theory of infinite space, *viz.*: (1) Greater simplicity of the Euclidean space compared with the Minkowski world; (2) possibility of the relativity of quantities which arise in the dynamically similar molecular-hierarchical world; (3) possibility of the cosmological fulfilment of the special theory of relativity; (4) necessity of irregular density and, in conjunction with the exclusion of a central point, of a distribution of matter in accord with experience. H. H. Ho.

1699. *The Michelson Experiment.* **N. v. Raschevsky.** (Zeits. f. Physik, 22. 6. pp. 401–404, 1924.)—On account of the velocity of light varying with the gravitation-potential, a negative result is not to be expected under the general theory of relativity. On the other hand, as the special theory of relativity implies the absence of a gravitation-field, which cannot be experimentally realised, a positive result cannot be regarded as contradicting the special theory itself. A. D.

METEOROLOGY AND GEO-PHYSICS.

1700. *Meteorological Observations at Geneva and the Great St. Bernard, 1923.* **R. Gautier.** (Arch. des Sciences, 6. pp. 116–143, March–April, 1924.) W. R. C.

1701. *The Book of Normals. Sections 4a and 4b.* (Meteorolog. Office, Air Ministry, M. O. 236 [Section 4], pp. 153–220, 1923.)

1702. *Krichewsky's Method of Fitting Frequency Curves.* **E. W. Woolard.** (Monthly Weather Rev. 52. pp. 91–94, Feb., 1924.)—This paper contains a summary of Krichewsky's method of curve-fitting and practical directions for its use. The curves obtained by this method appear to be as accurate as the Pearson curves, and are much easier to obtain. A. W. L.

1703. *Aerodynamic Resistance of Spheres, Shot Upward to Measure the Wind.* **L. F. Richardson.** (Phys. Soc., Proc. 36. pp. 67–80, Feb., 1924.)—The author's development of a new method of measuring the wind at different levels by shooting accurate steel spheres upward [see Abstract 2109 (1923)] has called for new experimental determinations of the resistance of the air to the motion of the sphere, and has provided two new methods of determining it. One method depends on finding the tilt from the vertical at which the sphere must be projected in order that a wind distribution, measured by some other means, may bring the sphere back to the gun. The other depends on comparing, under circumstances similar to those in the first method, the muzzle velocity with the time of flight of the sphere. The methods and results are set out in the present paper, drawing on the paper referred to above for the underlying theory.

A useful diagram is given, setting out the results of other investigators on the resistance to spheres under various circumstances, with a discussion of the differences between them. The turbulence of the air, the rotation of the sphere, and departures from spherical form (the latter particularly in the case of rubber pilot balloons used in meteorology for wind determinations) all play a part in producing divergent results.

A list of references is added. M. A. G.

1704. *Atmospheric Electrodynamics.* **F. Kaftan.** (Phys. Zeits. 25. pp. 114–115, March 1, 1924.)—Dynamic and thermodynamic considerations do not appear to suffice as explanations of meteorological phenomena. The author expresses the opinion that these are ultimately more closely bound up with the electrical condition of the atmosphere; and if this should prove so the fundamental problem for the study of weather on a world scale will be the question as to whether atmospheric electrical phenomena are cosmical or terrestrial in origin. W. A. R.

1705. *The Mass of the Atmosphere.* **J. Mascart.** (Bull. Astronomique, 3. No. 2. pp. 331–336, 1923.)—The height K of the homogeneous atmosphere has been determined by E. Mascart, assuming that the law of variation of density with height is $\rho/\rho_0 = f(s) = (1 - s)^4 . e^{-as}$, where $s = h/(R + h)$. If H is the height of the homogeneous atmosphere reduced to M.S.L., and a is taken as 660, the value of K/H is $(1 + \frac{1}{8})$. In the present paper the author deduces that $K/R = 1/\alpha$, and $H/R = 1/(\alpha + 4)$, from which $K/H = (1 + 4/660)$ if $\alpha = 660$. Reasons are given which show that the value $\alpha = 660$ is impossible, but no definite value can be obtained without an accurate knowledge of the density in the upper layers of the atmosphere. A. W. L.

1706. *Atmospheric Radiation.* **A. Boutaric.** (Comptes Rendus, 178. pp. 1303–1304, April 7, 1924.)—The nocturnal radiation r is the difference between the thermal emission σT^4 from a black body at the temperature T of the air, and the radiation ω received from the atmosphere; thus $r = \sigma T^4 - \omega$. In this equation ω is the only term depending solely on the meteorological conditions. The values of ω have been obtained from the mean values of the nocturnal radiation given by Kimball, Ångström, and the author. These values show that the atmospheric radiation varies fairly regularly throughout the year, being appreciably greater in summer, and also that it decreases with an increase in altitude. Such variations are not shown by the nocturnal radiation; it is suggested that they are chiefly due to changes in the temperature of the air and in the pressure of water vapour near the ground. The temperature of a black body encircling the earth, and giving the same radiation as the atmosphere, is found from the relation $\sigma\theta^4 = \omega$; the value of $T - \theta$ is generally between 20° and 30°, but increases at higher elevations. A. W. L.

1707. *Upper Cyclones.* **A. Defant.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 3–4. pp. 81–103, 1923.)—Observations have lead to the distinction between disturbances at lower levels in the atmosphere from those at higher. Both give rise to anticyclonic and cyclonic systems, and the formation of the upper cyclones is dealt with in this paper. Experiment and analysis deal with the influence of a large terrestrial projection, such as a mountain range. If there is a discontinuous layer, more or less well defined, between the stratosphere and the troposphere, and if the air streams are moving relatively to the projection, it is shown that the boundary is warped in an undulatory manner, and that vortices develop in the front or rear of the projection according to the velocity direction. The theory is applied to consider the effect of mountain ranges in the northern hemisphere. [Abstract 36 (1924).] W. A. R.

1708. *Cyclone Formation.* **F. M. Exner.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 1–2. pp. 1–16, 1923.)—Some experiments illustrating atmospheric circulation are described and compared with conditions prevailing in North America. Water, rotating in a basin, is heated at the periphery and cooled at the axis of rotation. The phenomena observed support the view that cyclonic phenomena arise through the interaction of the cold and warm air streams, but they do not support the discontinuity theory, at least not that form of it found in Bjerknes' polar-front theory. [Abstracts 640 (1912) and 39 (1924).] W. A. R.

1709. *The Periodicity of Thunderstorms.* **J. Gabriel.** (Comptes Rendus, 178. pp. 1020–1022, March 17, 1924.)—A study of the observations at Saint-Honorine-du-Fay for a period of forty years, shows that the periods of high or low thunderstorm frequencies agree closely with the wet and dry epochs. The most violent storms may occur during the periods of minimum frequency, and it is concluded that there is no marked change in the frequency when the temperature is abnormally high. A. W. L.

1710. *The Lunar Atmospheric Tide at Mauritius and Tiflis.* **S. Chapman.** (Roy Meteorolog. Soc., J. 50. pp. 99–112, April, 1924.)—Determinations of the lunar atmospheric tide at Greenwich, Batavia, Hongkong, and Aberdeen have been described in earlier papers; similar results are now published for Mauritius and Tiflis. The data employed are the hourly barometric readings for periods of 40 and 26 years respectively, and have been corrected for the daily non-periodic variation of the barometer due to the annual variation of pressure. The mean values obtained for the semi-diurnal component of the barometric variation, expressed in microbars, are: $51 \sin (2\tau + 98°)$ for Mauritius, and $27 \sin (2\tau + 65°)$ for Tiflis, τ being the mean lunar time reduced to angle. There is a marked annual variation in the tide, both the phase and amplitude being least around the December solstice; the change with lunar distance is somewhat irregular. Further determinations for other stations are necessary before the variations of phase and the seasonal changes in the lunar atmospheric tide can be explained. A. W. L.

1711. *Penetrating Radiation.* **V. Oberguggenberger.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 1–2. pp. 59–68, 1923.)—Measurements of the penetrating radiation were made in the neighbourhood of Innsbruck, where geological conditions are very varied. The results show that within a given formation the distribution of radio-active material is in general uniform. Sediments generally show lower activity than igneous and other crystalline rocks, but there is no dependence of activity upon geological age. The penetrating radiation increases with height. W. A. R.

1712. *Harmonic Law of Propagation of Seismic Tremors.* **G. Grablovitz.** (Accad. Lincei, Atti, 33. i. pp. 74–76, Jan. 20, 1924.)—The author takes the seismic tables of the British Association giving the values of the primary and secondary phases in terms of Δ, the angular distance from the epicentre, and expresses P and S as the sum of the harmonic functions of odd multiples of $\Delta/2$. The formulæ reproduce the data of the tables up to an angular distance of 150°, with a mean error of 1·32 sec. in the case of P and 1·96 sec. in the case of S. E. F.

1713. *An Earthquake,* 15 *March,* 1923. **G. Agamennone.** (Accad. Lincei, Atti, 32. ii. pp. 499–504, Dec. 16, 1923.)—The epicentre was at 43° 20′ N., 17° 10′ E. Greenwich; the velocity of propagation was initially 7½ km./sec., reaching a little above 8 km./sec. at a distance of 2000 km. A. D.

1714. *Tides and Ocean Currents.* **G. T. Rude.** (Frank. Inst., J. 197. pp. 73–97, Jan., and pp. 217–251, Feb., 1924.)—These two papers provide a readable and non-mathematical summary of the tidal and current work of the U.S. Coast and Geodetic Survey, mainly from an engineering and economic standpoint. Types and forms of tides, prediction, accuracy of tables, tides in rivers, mean sea-level, seismic waves, tidal power, types of currents are the main question dealt with. The papers also contain a description of two new instruments—the portable self-registering tide gauge, and the bifilar-suspension current direction indicator, both of which are the latest devices used by the Survey in this work. W. A. R.

1715. *Mediterranean Tides.* **R. Sterneck.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 10. pp. 667–694, 1922.)—This paper carries on the harmonic analysis of Mediterranean tides [Abstract 28 (1914)] by means of observations from 14 new stations. The results are tabulated. The tidal conditions show the influence of the Gibraltar stream and the proper tide of the Mediterranean basin. The data enable certain nodal lines to be established. W. A. R.

ASTRO-PHYSICS.

1716. *Statistics Discussion of Precise Astronomical Measurements: Parallaxes.* **E. B. Wilson** and **W. J. Luyten.** (Nat. Acad. Sci., Proc. 10. pp. 129–132, April, 1924).—An experimental determination of the actual determined values of parallaxes and of their probable error. The observatories of Allegheny, McCormick, Greenwich, Mt. Wilson, Yerkes, Sproul and Dearborn have determined parallaxes by photographic methods, and of these published results, Allegheny and McCormick have enough stars in common for statistical discussion; both determine their parallaxes by measuring at different epochs the position of the parallax star relative to comparison stars; these comparison stars may be in part the same at the two observatories and furnish to both the same systematic error. There should therefore be a small positive correlation between the two series, resulting in the probable error of the difference between the values of the individual parallaxes being less than the root of the sum-square probable error of the two. If $d\pi = \sqrt{r_A^2 + r_M^2}$, the series $d\pi/r = \alpha$ should be distributed in an error curve. The parameter of this should be such as to make a trifle more than half the values of α fall between $\alpha = \pm 1$, if the actual probable errors are those deduced from the discordances of the observations in the individual parallax determinations. For 273 values of α in the distribution curve plotted on arithmetic-probability paper the accordance with the normal error curve is perfect; the frequency of the difference $d\pi$ itself also follows a normal error curve, and the authors conclude that on the whole the McCormick parallaxes are 0″·0033 ± 0″·010 larger than the Allegheny, and the actual probable errors of the individual determinations are on the average about 25 % greater than those calculated from the observations. Results are also given for the comparison of Yerkes with the two other observatories. A. S. D. M.

1717. *Fitting Straight Lines to Data with Application to Sunspot Epochs.* **C. F. Marvin.** (Monthly Weather Rev. 52. pp. 89–91, Feb., 1924.)—A simplified arithmetical method of determining the value of the constants, in the equation of the straight line of best fit to any given data, is described. As an illustration of the method it is applied to the determination of the sun-spot period from 1820–1924. It is convenient to change the form of the equation $y = 1820 + a + bx$ into $a + b'x = (y - 1820 + 11x) = c$, and tabulate the differences, d, between values of c equidistant from the beginning and end of the period considered, *i.e.* $c_n - c_1$, $c_{n-1} - c_2$, etc.; these values are multiplied by weighting factors g, equal to $(n-1)$, $(n-3)$, etc. Then for the least square solution:

$b' = \Sigma gd/N$ where $N = 2\Sigma x^2 - \frac{1}{2}n(n - 1^2)$, and $a = \Sigma c/N - \frac{1}{2}(n - 1)b'$. The equation obtained for the sun-spot period is $y = 1822 \cdot 25 + 11 \cdot 31x$, and the observations show that the variations in the period are slight.

A. W. L.

1718. *Cosmical Physics ; Sunspots.* **J. Levine.** (Comptes Rendus, 178. pp. 1365–1366, April 14, 1924).—The author proposes an alternative explanation to Hale's for the polarity of sunspot streams. [See Abstract 1105 (1924)], namely, that solar eruptions form holes in passing through the photosphere, thus staining its bright surface. Their incandescent vapours, at a considerable height, are subjected to the rotational velocity of the sun, and fall back upon its surface at a different point, and at this point they form a second spot of opposite polarity and of more irregular appearance than the first.

A. S. D. M.

1719. *Sunspot Activity and the Solar Constant.* **A. Amerio.** (Accad. Lincei, Atti, 32. ii. pp. 391–394, Dec. 2, 1923.)—Empirical formula have been derived to express the relation between sunspot activity and the solar constant and possible theories of the connection are discussed. Support is given to the theory that increase in sunspot activity gives rise to a change in the absorbing power of the outer layers and corona due to eruption of material and hence alters the effective radiation.

A. Wh.

1720. *Law of Sunspot Polarity.* **G. E. Hale.** (Nat. Acad. Sci., Proc. 10. pp. 53–55, Jan., 1924.)—A formulation of a polarity law based on observations of the Zeeman effect in 2136 sunspot groups observed in 1908–1923. About 60 % of groups are bipolar, having the preceding and following spots of opposite magnetic polarity. The author describes the reversal of the sign of the polarity in the preceding and following spots of the northern and southern solar hemispheres after the minimum of solar activity, both in 1912 and 1922, and shows that at such times of solar minimum activity, four spot zones, characterised by distinct magnetic polarities may coexist on the sun, this position lasting for, perhaps, two or three years, after which the last low-latitude spots of the old cycle disappear. The author suggests that this indicates a solar cycle of 22·2 years' duration, not of 11·1. It is required to observe the Evershed effect at low levels in bipolar spots, in order to determine the sign of the dominant charge ; and if this is found to remain the same from cycle to cycle, the vortices of the spots represent whirls, and the reversal of the polarities means a reversal in the direction of whirl. [See Abstract 1105 (1924).]

A. S. D. M.

1721. *The Cause of the Great Velocities of the Solar Protuberances.* **W. Anderson.** (Zeits. f. Physik, 22. 5. pp. 322–327, 1924.)—Pringsheim's work is first briefly described, in which solar explosions are held to be an improbable explanation of the high velocities of the protuberances as also simple adiabatic expansion, and an electrical theory finds favour. Strutt likewise opined adiabatic expansion to be insufficient, and while an isothermal expansion could account for the observed velocity of 834 km. sec.$^{-1}$, yet such an expansion of the whole prominence, or of any appreciable fraction of it, would make it fill a space far in excess of the estimated volume of the stellar universe. Strutt states that the

velocity is acquired by the gas, not within the sun, but after emerging into the sun's atmosphere, and he seeks for the cause in the electrical forces of the latter. Although the entire literature contains no objection to the Strutt conclusions, yet the present author now seeks to show that these are by no means convincing. A current-impact theory for the protuberances is developed, although the author does not claim this to be the sole cause, notwithstanding its *containing the minimum hypothetical element*, and other contributory effects are discussed. The conception described is very plausible and the whole paper should be consulted.
H. H. Ho.

1722. *Variable Absorbtion in the Solar Atmosphere.* **A. Amerio.** (Accad. Lincei, Atti, 33. i. pp. 70–74, Jan. 20, 1924.)—Measurements of the ratio of the energy radiated from a small area at 60° or 75° from the centre to that radiated from the centre of the solar disc have been made and the two series of observations over a period of six months charted. A general agreement is apparent and the existence of variable absorbtion confirmed. A double *pyrheliometer* is described containing two thermo-elements which can be arranged at two points on a solar image. A doubly wound mirror galvanometer of special type, with the two coils at right angles, is used with this instrument. A. Wh.

1723. *Attempt to Determine Spectrographically the Meridional Component of General Current in the Sun's Reversing Layer.* **R. Sekiguchi.** (Imp. Marine Obs. Kobe, Japan, Mem. I. pp. 85–107. Feb., 1924.)—The author refers to previous investigations on the current circulating between the sun's pole and equator. [See Abstract 409 (1914), 657 (1915), 2238 (1922), 1103 (1924).] He gives the method of observation and reduction; the instrument (a Littrow spectrograph set in the horizontal position, facing south); the plates taken (one on July 27 and 28 and two on July 31 and August 1); the wave-lengths on the three plates measured; and deduces for the latitudes, ± 65°, that the poleward horizontal component of the mean velocity of the layers from which the respective absorption lines originate is $v_p = -0{\cdot}347$ km./sec., and that there is a tendency for the equatorward movement of the gases in the reversing layer to be accelerated with increasing height of the level. A. S. D. M.

1724. *Brightness of Lunar Eclipses.* **W. J. Fisher.** (Smithsonian Misc. Coll. 76. 9. pp. 1–61, Feb., 1924.)—The author gives three grades of brightness, based on the observation of "spots" or seas on the eclipsed moon: (*a*) With the naked eye or with field glasses; (*b*) with telescopes between 2 and 6 inches aperture; (*c*) with those above 6 inches. A table gives the particulars of the phase, air mass, grade, the sunrise-sunset line at mid-eclipse, place, observer, condition of sky, means by which observed, strength of twilight or moon's altitude, for 68 lunar eclipses. He finds that in the period, 1860–1922: (*a*) The southern zone of the earth's shadow is in general brighter than the central zone, and this again is brighter than the northern; (*b*) there is no obvious way in which an effect of the solar cycle of activity can be disentangled from the effects of dust; (*c*) the greater opacity in the earth's northern shadow may perhaps be accounted for by the fact that the great deserts are largely in the earth's northern hemisphere, and the dust from these is carried by the trade winds parallel and not crosswise to the equator;

also by the greater number of dust-erupting volcanoes, in the northern hemisphere, and dust ejected from some of these has been known to penetrate well up towards the stratosphere; (*d*) there is not much difference in brightness of the eclipsed moon due to its position at apogee or perigee; (*e*) an effect depending on longitude, as suggested by Smith in 1825, does exist, but its maximum phase is quite 45° away from what he expected, and winter eclipses are bright, spring eclipses dim, summer and autumn eclipses intermediate and not very different from each other. A. S. D. M.

1725. *On the Breadth of the Hydrogen Lines in Stellar Spectra.* **E. O. Hulburt.** (Astrophys. J. 59. pp. 177–180, April, 1924.)—When the Stark theory of the broadening of the Balmer lines of hydrogen is combined with the Saha theory of high-temperature ionisation, it is found that in order to account for the broad Balmer lines observed in many stellar spectra, the pressure in the stellar envelope must be as great as several atmospheres. This seems to contradict evidence from other sources which points to much lower pressures. The assumption of a considerable number of free electrons in the atmosphere might explain the discrepancy. AUTHOR.

1726. *Astrophysical Determination of Average Life of Excited Calcium Atom.* **E. A. Milne.** (Roy. Astron. Soc., M.N. 84. pp. 354–363, March, 1924.)—It is taken that atoms in the high-level chromosphere are supported by radiation pressure, and consist almost solely of singly ionised calcium above 8500 km. on the sun [see Abstract 616 (1914)] and an equal number of free electrons. They emit radiation of wave-lengths $\lambda\lambda 3933$, 3968, and the energy-value of a single 1π-state is chosen, so that the difference $(1\sigma - 1\pi)$ corresponds to the mean wave-length $\lambda 3950$. The author describes the mechanical equilibrium in which the normal 1σ-state is transformed to the excited 1π-state and back again, and shows that the emissions will be random in direction and the recoil momentum zero, on the average, but that the momentum acquired in absorption will be principally outward, since the atoms at such high levels are exposed only to radiation on the side exposed to the sun. If τ is the time spent in the 1π-state and τ' in the 1σ-state, the values are found by $\tau/\tau' = r \times 1\cdot 18 \times 10^{-3}$ and $\tau + \tau' = 4\cdot 6 \times 10^{-5}$, where r is the ratio of the intensity in the centre of the line to the intensity in the adjacent continuous spectrum, and is less than 1. From measures by Schwarzschild, the value of r is taken as $0\cdot 11$, whence $\tau = 0\cdot 6 \times 10^{-8}$ sec. Since $\tau = (r/4\,mgc) \times (h\nu/e^{h\nu/kT} - 1)$, the author finds that for Ca^+ high-level chromospheric equilibrium is not possible for a star with the same value of g as the sun and a temperature below 4400°. Taking the value $r = 0\cdot 11$ for the sun, and $\tau = 0\cdot 6 \times 10^{-8}$ sec. for Ca^+, he finds for Capella, for Sirius, and for Plaskett's O-star, $r = 0\cdot 010$, $0\cdot 0043$, and $0\cdot 00035$ (or $0\cdot 00019$) respectively, and for the last star he suggests that atoms of ionised calcium will be continuously expelled under radiation pressure. He also gives the general conditions for the chromospheric equilibrium of sodium, hydrogen and helium. A. S. D. M.

1727. *Recent Work in Stellar Physics.* **E. A. Milne.** (Phys. Soc., Proc. 36. pp. 94–113, Feb., 1924.)—Recent work in classifying stellar spectra shows that with very few exceptions they can be arranged in a sequence, and indicates that spectral type is correlated with effective temperature. Bohr's theory of spectra and Saha's application of it to stellar atmospheres has made it possible to explain this correlation. Further, it is observed that there are differences between the spectra of giant and dwarf stars belonging to the same types, and these can be explained as due to differences of pressure.

A brief review is given of recent work on spectroscopic parallaxes, colour indices, effective wave-lengths, details of intensity-differences throughout the spectrum, direct measurements of heat, and determinations of angular diameters of stars. The results all agree in indicating that spectral type is mainly a function of effective temperature, and they agree as to the order of magnitude of the temperatures and even to numerical values for those of late-type stars, though they differ somewhat for the early types. Effective temperature is also a function of absolute magnitude, but the paradox is noted that giant stars have lower effective temperatures than dwarfs of the same spectral type, and yet show a stronger development of enhanced lines. This, however, is explained by the much smaller pressure gradient in a giant; and Adams' empirical correlation of intensity of certain enhanced lines with great intrinsic luminosity results from the fact that strong ionisation indicates low pressure, due to low surface value of gravity, due to large radius, and this implies large disc area and consequently large intrinsic luminosity.

The order in which lines due to neutral atoms, and lines due to ionised atoms, may be expected on the quantum theory to appear, reach a maximum and disappear, in the sequence of stellar spectral types, is discussed, and a diagram shows the relative intensities of various absorption lines as actually observed in the sequence. It is pointed out that the absolute value of τ (the average time during which an atom remains in an excited state) could be derived from stellar evidence if the effect of g (surface gravity) could be distinguished from the effect of pressure, which should be quite possible; and that it might equally well be deduced from observations of certain lines in the solar chromosphere. Modern spectral theory has solved many problems of astrophysics; in return, astrophysics has once again something to contribute to the physics of the atom. M. A. E.

1728. *Summary of Study of Stellar Distribution.* **H. Shapley** and **Annie J. Cannon.** (Am. Acad., Proc. 59. pp. 215–231, March, 1924.)—Results of discussion of the Henry Draper Catalogue of stars brighter than 8·25 magnitude. [See Abstracts 464, 465, 466, 878 (1923), and 814 (1924).] Other points brought out are: The G stars are predominantly dwarfs and lie within the nearby region of fairly constant star-density. There are nearly twice as many naked-eye KO stars as in any other subdivision. About 60 % of bright stars are earlier than the sun, and some 20,000 stars have spectra essentially identical with that of the sun. The distance of the dark matter, obscuring Taurus, is not over 300 parsecs; of that, making the Great Rift in the Milky Way, part comes as near as 200 parsecs; the distinct nebulosities in the Scorpio-Ophiuchus region are 200 and 300 parsecs distant. Of the Local Cloud, 90 % of the 346 early B stars brighter than 5′·25 (visual) belong to the Local Cloud, 10 % to the general galactic field. The average median galactic latitude for B stars between 7′·26 and 8′·25 (visual) is −1°·4, and the sun is 50 light years to the north of the galactic plane. The diameter of the Local Cloud is irregular in form, but of the order of 1000 parsecs. Of the Galactic Concentration, F and G stars are largely dwarfs and only slightly concentrated towards the Galaxy. Longitude is important because of the particular star clouds, the dark nebulosities, and the eccentric position of the sun. Asymmetry in longitude is a striking characteristic in the distribution of M*d* variables. A stars preponderate in low galactic, K stars in high latitudes. Of the distances and numbers of stars, the great majority of stars in the catalogue are within 1000 parsecs. There are 3600 early B stars, of which 20 % are farther away than 1000 parsecs, and the faintest (visual magnitude 11·6) are more than 3000 parsecs away. The volume explored for B stars is 2000 times as great as that in which dwarf G stars are observed. The great majority of stars are extreme dwarfs, showing that a star spends most of its life in the later spectral stages; there are about 2000 times as many solar dwarfs as early B stars, and 350 times as many solar stars as M giants. A. S. D. M.

1729. *Absorbing Power of Stellar Atmospheres.* **Salet.** (Comptes Rendus, 178. pp. 1474–1475, April 28, 1924.)—The total energy received from stars can be measured with the radio-micrometer or the thermo-electric pile, and Coblentz has shown that the proportion of visible light-radiation to the total radiation is, on an average, twice as great for A and B type stars as for solar stars. Theoretically it should be less. Nordmann therefore concludes [Abstract 1568 (1920)] that the general absorptive power of stellar atmospheres decreases from the solar type to the higher-temperature types. It must be remembered, however, that with A and B stars the maximum energy is in the more refrangible part of the spectrum, and that absorption is more effective here than in the visible part, so that we should rather conclude that the A and B stars have powerfully absorbing atmospheres. Moreover, our own atmosphere also absorbs radiations from the stars, and especially the ultra-violet rays. The proportion varies also between stars of the same spectral type. This may be due to various causes, such, for example, as the presence of a companion of lower temperature; but if due to differences of absorptive power in the atmospheres of different stars of A and B types, the absorption must be more effective where the visual magnitude is equal but the total energy received is less. M. A. E.

1730. *Relation Between Masses and Luminosities of Stars.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 84. pp. 308–332, March, 1924. Nature, 113. pp. 786–788, May 31, 1924.)—By means of the theory of the stellar absorption-coefficient, which in a previous paper [Abstract 1109 (1924)] was used to calculate the absolute magnitude of Capella, it should be possible to determine differentially the absolute magnitude of any gaseous (giant) star whose mass and effective temperature are known. Taking 36 stars for which these data are reasonably well determined, it seems that the formulæ of the theory predict correctly the absolute magnitudes of all, though more than half the number are dwarfs; and it appears that the low luminosity of the dwarfs is fully accounted for by their comparatively small mass, without appeal to any other physical difference. This result is in conflict with the current view that dwarf stars are too dense to follow the laws of a perfect gas, and that their low luminosity is due to deviation from the gas laws. It is argued that dense stars may still possess the compressibility of a perfect gas, for, owing to high ionisation, stellar atoms have only about 1/100,000 of the bulk of ordinary atoms, and therefore failure of the laws of a perfect gas need not be expected until an enormously high density is reached. The effect of the high electric charges of the ionised atoms in resisting compression has been considered, but it appears that it would not appreciably affect the stars considered. Notwithstanding a wide range of physical condition in the interior of the stars discussed, the ionisation level is not very different in any of them. The assumption that the same molecular weight can be assumed for all of them is thus closely justified.

The extent of the conflict between the present results and the current theory of stellar evolution depends on whether we admit that the mass of a star diminishes to an important extent by radiation of energy during its lifetime. If the star gradually burns itself away in liberating subatomic energy, the sole divergence between the present theory and the giant and dwarf theory is that diminishing brightness in the dwarf sequence is attributed to decreasing mass and not to decreasing compressibility. The conception of an ascending and descending series, judged by effective temperature, is thus retained, although, as judged by internal temperature, there is probably a continuous ascent. By way of appendix, a discussion is given of the fundamental quartic equation of the theory of radiative equilibrium, in which account is taken of the gradual increase of molecular weight from the centre to the boundary of the star. M. A. E.

1731. *Micrometric and Interferometer Measurements of Double Stars.* **M. Maggini.** (Accad. Lincei, Atti, 33. i. pp. 186–189, March 2, 1924.)—When the values of the interferometer measurements of double stars are tabulated against those obtained by micrometry, a systematic difference appears. If I be the interferometer and M the micrometer values, I − M is a positive quantity which decreases regularly as the separation increases. The error is traced to diffraction, which causes an apparent displacement of the images of close stars and introduces a micrometric error. The magnitude of the error is worked out for the instruments used for this class of work in the observatories of Yerkes, Lick, and Nizzo. A. Wh.

1732. *Motions of Spiral Nebulæ.* **W. M. Smart.** (Roy. Astron. Soc., M.N. 84. pp. 333–353, March, 1924.)—An investigation into the proper motions of the seven spiral nebulæ measured by van Maanen. The plate constants of these were deduced from about 20 comparison stars in the usual way, and from these comparison stars the proper motions of the n nebular points are derived. Van Maanen adopted three methods of obtaining X and Y, the components of the proper motion of the whole nebula. The author first inquires into the errors which may be introduced into X and Y by proper motions of the comparison stars themselves, but finds these negligible; next into the probable errors in X and Y by van Maanen's methods, and finds that these may be greater than the values of X and Y; third, he proposes two methods of his own: (1) by a *selection* of groups of nebular points so that the mean motion of a group at (r_1, θ_1) is compared with the mean motion of a similar group at $(r_1, \theta_1 + 180°)$, and so on; (2) since at a constant distance from the centre and in the plane of the nebula the values of the radial (v) and the rotational (w) motion are constant if the nebula region is divided into a number of rings (circular or elliptical according as the inclination is zero or not), a least square solution can be made for v, w, X and Y for each ring. The author applies the first method to six of the spirals and the second to M 51, and finds that van Maanen's proper motions are real and of the right order of magnitude. Their mean proper motion is about 0·″01 per annum, and if their mean cross velocity is 600 km./sec., their mean parallax is about 0·″0001. He finds, further, that in this case M 81 is no exception to the rule that spiral nebulæ are receding from the Milky Way. [See Abstract 804 (1924).] A. S. D. M.

1733. *Diffusion Theory of Comets.* **H. Mache.** (Phil. Mag. 47. pp. 724–735, April, 1924.)—When a glass bead is fused above the cone of a Bunsen burner flame, the form of the luminous sodium vapour is like that of a comet near the sun. The author finds, by making two simple assumptions, that the isothermal surfaces are those of rotation about the z-axis, and are given by the equation, $\vartheta r = \mathrm{A} \, . \, e^{c(z-r)/2k^2}$. These shapes vary with the velocity of flow of the gas through the intermediate forms between a sphere and a paraboloid, the edges being most defined near the glass bead and diminishing in distinctness with distance from it. Applying these deductions to comets, the author finds the analogy to the Bunsen gas flame in the coronal gas, which (as Saha has shown) need not be of small atomic weight. The green coronium line has been traced at a height of 20′, and the corona itself to 6° or 7° from the sun; and he concludes that if such a gas has once been raised to such heights by radiation pressure, it can leave the sun permanently, for if the light-pressure is greater than the solar attraction it will remain greater. The magnitude of the velocity may be very large, and will diminish but slowly with increasing distance from the sun. If the velocity be so large that the atomic ions become positive atomic rays, the action on the cometary gas will no longer be one of simple impact; the cometary gases will diffuse with almost molecular velocity into the outward stream of gas driven from the sun by radiation, just as the sodium vapour is developed from the bead. The author interprets the essential features of comets; the concentric envelopes; the sharp and the diffuse boundaries of the tails; and Bredichin's three types of tails, though these are not interpreted as Bredichin did. But if it should prove that the atomic ions which leave the sun are accelerated by light-pressure until they attain the velocity of atomic rays, they will excite luminosity in the molecules of the cometary gas and cause it to stream. This action on the cometary gas is not directly by light-pressure, but through the agency of matter transmitted with large velocity away from the sun. A. S. D. M.

1734. *Luminosity and Density Functions.* **F. H. Seares.** (Mt. Wilson Observat. Contrib. No. 271. Astrophys. J. 59. pp. 11–29, Jan., 1924.)—The luminosity and density functions of Kapteyn and van Rhijn are combined to give an apparent luminosity function, which expresses the distribution of absolute magnitude for all stars brighter than apparent magnitude m_0. Values of the function for successive limits to $m_0 = 11\cdot0$ are found and compared with counts made of the helium stars of Kapteyn and of the star of other types in the tables of spectroscopic parallaxes. Beyond $m_0 = 5\cdot0$ the data are incomplete. To this limit the agreement is good for absolute magnitude $\mathrm{M} \geqq +1\cdot5$. For $\mathrm{M} < 0$ there is an excess in the calculated value, and for $\mathrm{M} = 0 - +1\cdot5$ an excess in the observed number, but the agreement is within the uncertainties of the data.

In calculating absolute magnitudes from parallaxes, Strömberg's observation that the solar velocity is greater with respect to dwarf than to giant stars must be allowed for, and may partially explain the apparent systematic difference between mean and measured parallaxes. The luminosity function being of the form of an error function where M_0 is the mode, it has been claimed that the excess of low luminosities observed among the nearer stars shows that the value of M_0 should be increased. This view is supported, though Luyten's conclusions on this subject are invalidated by selection of data. In general the luminosity and density functions, derived principally from faint stars, show good agreement with data both for faint and bright stars. A. Wh.

1735. *Effects of Atmospheric Dispersion upon Determinations of Stellar Parallax.* **F. Slocum.** (Astrophys. J. 59. pp. 108–113, March, 1924.)—Systematic errors in stellar parallaxes determined by the trigonometrical method appear to be different for stars of different colours. It has been suggested that this may be due to atmospheric dispersion. To test this a pair of stars, one red, the other blue (spectral types, Mb and B5), were selected, and the field photographed with the 20-inch refractor of the van Vleck Observatory at hour angles varying from 0h. to 4h. 30m. Isochromatic plates and a colour filter were used. The positions of the coloured stars were measured with respect to six comparison stars of about the 10th magnitude. From 40 exposures on 20 plates the displacement in zenith distance at altitude 45°, relative to the group of comparison stars, is for the red star $-0''\cdot025 \pm 0''\cdot019$, and for the blue star $+0''\cdot016 \pm 0''\cdot019$. The signs are as would be expected, refraction raising the blue star more and the red star less than the faint comparison stars, probably of about type G. For parallax work, only the components of these values in right ascension need be considered, and these are so small that for plates taken within half an hour of the meridian no appreciable errors due to atmospheric dispersion need be feared. AUTHOR.

1736. *Spectroscopic Parallaxes of* 100 *B-Type Stars.* **D. L. Edwards.** (Roy. Astron. Soc., M.N. 84. pp. 366–377, March, 1924.)—In an earlier paper [Abstract 875 (1923)] it was shown that the absolute magnitude of a B-type star bears such a well-defined relation to the intensities of certain helium lines in its spectrum that the relation affords a method of determining the parallax of the star. Since then much valuable material has been published on this subject, especially Rasmuson's memoir on moving clusters and the McCormick Observatory list of trigonometrical parallaxes of B-type stars. Using these new data, reduction curves of great precision have been derived. The two pairs of lines described before, $H\gamma - \lambda4388$ and $H\delta - \lambda4144$, and also the pair $H\gamma - \lambda4471$, have been used. The curves thus obtained are compared with those derived from the results of Plummer, Charlier, and van Rhijn, and although there are sometimes large differences for individual stars, the general agreement is good. Parallaxes of 100 stars are given, and are compared with parallaxes from Mt. Wilson Observatory and other sources. For those stars of the hundred which belong to moving clusters, the mean group parallax is $+0''\cdot0090$, and the mean spectroscopic parallax now derived is $0''\cdot0085$; for those whose trigonometrical parallax is known, the mean is $0''\cdot012$, and the mean spectroscopic parallax is $0''\cdot013$. These results confirm the Mt. Wilson assumption of a relation between spectral type and absolute magnitude, especially when Adams and Joy's division into sharp-line and diffuse-line stars is taken into account. It is possible that the measurement of the intensities of the helium lines simply amounts to an accurate method of subdividing the spectral types. M. A. E.

1737. *Spectral Classes and Hypothetical Parallaxes of 100 Faint Stars of Large Proper Motion.* **W. J. Luyten.** (Lick Observat., Bull. 11. No. 351. pp. 127–129, 1924.)

1738. *E. W. Brown's Suggestion to Apply Delaunay's Lunar Theory to Jupiter's 8th Satellite.* **J. Trousset.** (Bull. Astronomique, 3. No. 2. pp. 337–340, 1923.)—It is indicated that Delaunay's series, which proceeds by powers of m (ratio of means of motions of satellite and of planet), e and γ (eccentricity and sine of semi-inclination of the satellite), are not carried far enough for Jupiter viii, for these terms are much greater than in the case of the moon. The author refers to the thesis for his doctorate in 1913, where he calculated the numerical values of the sums of the series for $m = -0\cdot172$ (the case of Jupiter viii) and for all the terms where p (the sum of the exponents $e, \gamma, \ldots$) is less or equal to 4, and compares his results with those suggested by Brown. In this thesis he had also found approximate numerical values for m, e, and γ, for Jupiter viii. A. S. D. M.

1739. *Comparison of Average Velocity of Binaries and Single Stars.* **J. H. Oort.** (Astron. J. 35. pp. 141–144, April 4, 1924.)—There seems to be a relation between absolute magnitude and average velocity; there may be equipartition of energy between early and late type spectra [see Abstract 1559 (1922)]; the author therefore inquires into the comparative velocities of double and single stars. He finds no appreciable difference in mass between the single stars and the brighter components of the doubles, and in the material used the average mass of the binary system comes out as about 1·7 that of the single star. A table gives the average radial velocities freed from solar motion of the two classes for types A0–A9, B0–B9, F0–F9, G0–G9, and K0–K9. For types A and F there seems no difference in average velocity, though the binaries have 1·7 times the mass of the singles. For G and K the binaries have lower velocities, and this may be due to their companions being of A or B type, so that they should themselves, therefore, be placed in these classes, both on account of their motions and of their galactic condensation. A. S. D. M.

1740. *The Absolute Magnitudes of Long-Period Variable Stars.* **P. W. Merrill** and **G. Strömberg.** (Mt. Wilson Observat. Contrib. No. 267. Astrophys. J. 59. pp. 97–107, March, 1924.)

1741. *Space-Velocities of Long-Period Variable Stars of Classes Me and Se.* **G. Strömberg** and **P. W. Merrill.** (Astrophys. J. 59. pp. 148–154, April, 1924.)—*Computation of Velocity-Ellipsoids.*—The three rectangular velocity-components of the motion relative to the sun of 80 long-period variables of spectral classes M and S have been computed from the radial velocities, proper motions, and absolute magnitudes. The stars were divided into two groups according to their spectra; (1) M1e to M6e; (2) M7e, M8e and Se. The elements of the velocity-ellipsoids for each group were determined, and are given in Table I in galactic coordinates, and in Table II in equatorial coordinates. The direction of the major axis is about the same in both groups as for other classes of stars, but the dispersion of the velocities is much larger, especially for the first group.

The asymmetry in the velocity distribution is very marked among these stars, as evidenced by the fact that the first group (containing the fastest moving stars) is shifted farther from the origin toward the third quadrant of the galactic longitude than is the other group. AUTHOR.

1742. *Photometric Observations of Some Variable Stars.* **S. Aurino.** (Accad. Lincei, Atti, 32. ii. pp. 388–391, Dec. 2, 1923.)—Observations over the period February to July, 1923, of the variable stars X Cancri, T Cancri, R Leonis, RX Virginis and R Virginis are given. A. Wh.

1743. *Spectral Types and Colour Indices of the Components of Double Stars.* **G. Abetti.** (Accad. Lincei, Atti, 32. ii. pp. 488–492, Dec. 16, 1923.)—A table is shown containing 35 double stars from the Burnham catalogue with the types, colour indices, parallaxes, and absolute magnitudes of each component. Then arranging the spectral types in their order of evolution, primarily classifying into giants, intermediates, and dwarfs, and plotting against the difference of the colour indices of the components, a smooth relation is apparent. Similarly the variation of the logarithm of the density of either component with the order of evolution shows similar regularities. A. Wh.

1744. *Study of Variable Star SX Herculis.* **W. J. Luyten.** (Lick Observat., Bull. 11. No. 351. pp. 124–127, 1924.)—Table 8 gives a list of observations made with the Lick 36-in. and the Mt. Wilson 10-in. refractor and 100-in. reflector, by the author, between May 24 and October 12, 1922. The bright hydrogen lines seem to develop very shortly after minimum and disappear 30–40 days before the next minimum. A rediscussion of the light variation elements by Luizet and the author visually, and by Jordan photographically, indicates that Jordan's period of 102·8 days is probably nearest the true one. Luizet found the minimum of the light curve sharply defined; the author found the light of both phases flat as in a sine curve; "Harv. Bull." 774 gave its photographic light curve like the brighter Cepheids in the Magellanic Cloud. But Cepheids give a constant range in magnitude and period, and the galactic Cepheids have spectra clustering round G and (except in W Virginis) show no bright lines. SX Herculis, with varying maxima and minima, has high galactic latitude, spectral class varying from K2 to M*b*, and variable bright lines—thus differing from the average Cepheids. It resembles the long period M*d* variables in the time of reappearance of the bright lines, but differs from them in maintaining the relative intensities of these lines. Its length of period lies between those of the Cepheids and of the M*d* variables, and these do not fit on the period-luminosity curve. Shapley estimates its visual magnitude as −7m., corresponding to a parallax of 0″·0001; the author finds for it the values $M_{S,H} = +0^m\cdot 9.$, $\pi_{S.H} = 0''\cdot 042$, and tangential velocity = 31 km./sec., with space velocity = 36 km./sec., Shapley's value would give a tangential velocity of the order of 1300 km./sec., and place the star in a sparse region 10,000 parsecs away.

A. S. D. M.

1745. *Radial Velocity of ε Aurigæ.* **H. Ludendorff.** (Preuss. Akad. Wiss. Berlin, Ber. 9. pp. 49–60, 1924.)—This star has been known to be variable since 1821, and has been classed as irregular. The author showed, however, from a discussion of all available observations of its light-changes, that it is an Algol variable of very long period, *viz.* 27·1 years (Astronomische Nachrichten, 164. p. 81, 192. p. 389.) The minimum brightness, which is 0·74 magnitude less than the normal, lasts for about 340 days, and the periods of decreasing and increasing brightness are about 180 days each. The middle of the next minimum should be in May, 1929. The spectrum is *c*F5, and it is therefore doubtless a super-giant like all *c*-stars; its absolute magnitude has been found at the Mt. Wilson observatory to be −2·0. In the present paper the period is deduced from the varying radial velocity obtained from measurements of 182 spectrograms taken by the author and Eberhard between 1901 and 1913 and some data published by various American observers between 1897 and 1920. The curve derived from these observations agrees very well with the period of 27·1 years deduced from the light-changes, in every way confirming the hypothesis of an eclipsing companion, and provisional elements of its orbit are given. It seems necessary to assume that the companion is seven times as long in the direction of motion as in the direction at right angles to this, which suggests that it may resemble a swarm of meteors rather than a star. The chief star must be assumed to have an extremely low density and large diameter.

Superposed upon the long-period curve is another of about 150 days, but this varies greatly in length and amplitude, and cannot possibly represent the movement of a third component. For (1) there is no change in the character of the spectral lines and no trace of a second spectrum during the whole period of normal brightness, and only during minimum and the period of increasing brightness have changes been observed, the lines becoming less clearly defined and unsymmetrical; and (2) the irregularities in the short-period curve are too great and too rapid to be accounted for by gravitational disturbance of a close companion caused by the eclipsing long-period companion. No plates have been obtained at Potsdam during the period of decreasing brightness, and the cause of the peculiar spectral changes cannot profitably be discussed until these are available and a large spectral region has been photographed. It is, however, suggested as a probability that during minimum we see light from the bright component coming to us through the outer atmosphere of the companion, and anomalous dispersion perhaps plays a part here.

In five other *c*-stars which are spectroscopic binaries the radial velocity also appears to be irregular, and the same is the case with the related *ac*-stars, and especially the δ Cephei variables. As with ε Auriga, therefore, the radial-velocity curve cannot be explained by simple orbital motion of two components, yet it is improbable that all are triple systems. It is more likely, especially since all are presumably of very low density, that the irregularities are due, not to orbital motion, but to some such cause as pulsation, which has been suggested for the δ Cephei *ac*-stars. M. A. E.

1746. *The Orbit of the Spectroscopic Binary δ Trianguli.* **J. A. Pearce.** (Lick Observat., Bull. 11. No. 352. pp. 131–132, 1924.)

1747. *Double Cluster in Perseus.* **C. Parvulesco.** (Bull. Astronomique, 3. No. 3. pp. 393–434, 1923.)—The chief results, in the order as given in the paper, are: A determination and discussion of the photographic magnitude of 7500 stars in the cluster and neighbourhood. The cluster is double, and between *h* and χ Persei there is a zone sparse in stars which is taken as the boundary between them. In the clusters there are stars of all apparent magnitudes between 6·22 and 16; that is to say, the dispersion in luminosity is 1 to 10,000. Curves are given showing the frequency for different magnitudes in the regions of *h* and χ Persei, and the relation between absolute and apparent magnitudes and spectral types in the cluster *h* and the cluster χ. Adams' linear relation is indisputable, but it is here a band and not a geometrical curve. This is due either to the assumption that in these clusters stars of the same apparent magnitude are of the same absolute, or to a genuine physical variation; the latter is probably the effective reason. The brightness of a star can vary much without sensible alteration in its spectral type. This caused van Maanen to conclude that the theories of Adams and Russell do not hold good for the Perseus clusters. The parallax of *h* is 0″·0021 and of χ is 0″·0020. The mean velocity of a star is proportional to the amplitude of its motion. It is also in inverse ratio to the square root of the mass, and therefore the mean mass of the stars is in inverse ratio to the square of the amplitude of the movement. As in other clusters, no double stars are found. The clusters show a stratified condition or a tendency to conform to such. A and B, the brightest types, have a quarter of the amplitude of the faintest types, K and M, which reach to the periphery of the clusters. The amplitudes, mean velocities, and mean masses being related, if we know the amplitudes we can calculate the masses. These relations are given for B, F, G and K. If the emission power of a K-giant is the same as that of a K-dwarf, then a K-dwarf is 60,000 times as dense as a K-giant. We can derive the relative ages of clusters from the presence or absence of the giants of a certain type; the Perseus cluster is less aged than a cluster containing only F and K dwarfs. The stars surrounding the double cluster have large proper motions, which are nearly parallel to the plane of the Milky Way, which seems to be the fundamental plane for stellar motions, at least of those of faint stars. No internal proper motions with respect to the centres of gravity are apparent in the double clusters. No correlation appears to be between the proper motions, the photographic magnitudes, or the spectral types. Adams and van Maanen have found a radial velocity for the double cluster of — 43·1 km./sec. ± 0·9 km./sec. [See Abstract 1114 (1924).] A. S. D. M.

1748. *Photometric Variation of X and T Cancri.* **S. Aurino.** (Accad. Lincei, Atti, 32. ii. pp. 483–487, Dec. 16, 1923.)—The photometric curves for X and T Cancri are given for periods between February and July, 1923, and some discussion of the curves is also included in the paper. A. Wh.

1749. *Spectrographic Observations of Mira Ceti, R Leonis, T Cephei, and R Serpentis.* **E. B. Frost** and **(Miss) F. Lowater.** (Astrophys. J. 58. pp. 265–279, Dec., 1923.)—The authors confine themselves chiefly to the two first stars, and give plates of their spectra and a list of the early papers dealing with them. They find that for the four stars the velocity is practically constant, though different from star to star, but that the bright hydrogen lines give a smaller positive value for the velocity than the dark lines, and this is approximately the same difference for all four stars, and is of the order of 20 km./sec. They therefore suggest that the bright hydrogen lines may be due to eruptions, similar to the eruptive solar prominences, and that the various broadenings of the hydrogen lines may be caused by the various inclinations to the line of sight of these eruptions; also that as these eruptions may be periodic, and as the bright lines in Mira disappear at minimum, the variation in magnitude may be due to the varying speed, quantity, and height of the gas projected. They point out that the difference in displacement of the bright and dark lines cannot probably be due to pressure, as this should be small as in the case of the sun, where it is but the small fraction of an atmosphere. They find that most of the bright lines are due to the rarer elements, and that the presence of titanium oxide indicates a comparatively low temperature in these stars, so that if the bright lines indicate a high temperature, they must arise from a body separated from the source of the bands. This paper has been held over from publication since 1917, and therefore does not discuss the work made at Mt. Wilson (chiefly) since that date. A. S. D. M.

1750. *Constitution of Mira Ceti Variables.* **la Rosa.** (Accad. Lincei, Atti, 33. i. pp. 3–7, Jan. 13, 1924.)—It is shown that the light curve of this type of variable can in general be explained readily if two hypotheses are allowed: (1) that the velocity of light is compounded with the velocity of its source; (2) that such " double " stars are in general complex stars. A. Wh.

1751. *Photometric Variations of R Leonis, RX Virginis and R Virginis.* **S. Aurino.** (Accad. Lincei, Atti, 33. i. pp. 17–20, Jan. 13, 1924.)—R Leonis is observed from February to July, 1923. A minimum is found at March 18, 1923. A value at Harvard, May 15, 1922, gives the period 307 days as compared with 313 days previously found. RX Virginis is observed from February to July, 1923. The curve is somewhat irregular, oscillations occurring with a period which varies, but is about a month. R Virginis is observed from February to July, 1923. A period is deduced of about 80 days. A. Wh.

LIGHT.

1752. *Extinction Coefficients of Some Acids and their Salts in the Ultra-violet.* **J. C. Ghosh** and **S. C. Bisvas.** (Zeits. Elektrochem. 30. pp. 97–103, March, 1924.)—It appears to be a general rule that the strong acids and their sodium and potassium salts show corresponding values of the absorption coefficients in the ultra-violet. Nitric acid and potassium nitrate give amongst themselves identical absorption coefficients, whilst a little different from sodium and barium nitrate. The reason for this variation is not clear. Passing over to the weak acids, the absorption coefficient markedly changes in these with the salt formation. Comparing trichloracetic acid with acetic acid, it is established that, whilst the first and its sodium salt possess throughout similar absorption spectra, with the last named acid and its sodium salt a certain variation in the absorption coefficient exists. The absorption region remains confined very nearly to the same portion of the spectrum.

J. J. S.

1753. *Testing Coloured Material for Fastness to Light.* **H. S. Thayer.** (Am. Illum. Eng. Soc., Trans. 19. pp. 336–348; Disc., 348–350, April, 1924.)

1754. *Refractive Indices of Calcite and Aragonite.* **W. L. Bragg.** (Roy. Soc., Proc. 105. pp. 370–386, April 1, 1924.)—Accepted values for the refractivities of Ca, C, and O atoms in calcite and aragonite show that more than 80 per cent. of the total refractivity is due to the O atoms, and the explanation of the strong bi-refringence exhibited by these crystals must therefore be sought in the structure of the CO_3 groups, about which X-ray analysis gives information. A comparison of the refractivities of several molecules or ions containing 3 oxygen atoms leads to the conclusion that the carbon atom has a negligible refractivity. The oxygen atoms are thus more highly polarised by an electric field than are the other atoms in the crystal. An oxygen atom is more strongly influenced by the other two atoms in its own group than by neighbouring atoms. The result of this mutual influence of atoms in the same groups is that they are more strongly polarised by an electric field parallel to the plane of the group than by one perpendicular. Hence the refractive index of the crystal is greater when the electric vector is perpendicular to the trigonal axis of calcite than when it is parallel to the axis. The same is true of the pseudo-hexagonal axis of aragonite. Excluding the effect of atoms in other groups, values of the two indices are calculated and found to be in fair agreement with those observed. When account is taken of the effects of other oxygen atoms better agreement is obtained. The explanation may be extended to other rhombohedral carbonates. Similar considerations lead one to expect weak bi-refringence in sulphates, and this is the case.

G. A. S.

1755. *Optical Constants of Opaque Metal Films.* **K. Lauch.** (Ann. d. Physik, 74. 1. pp. 55–79, April, 1924.)—The technique of cathode sputtering is investigated, and numerical values of current, voltage, time, etc., are cited which lead to the obtaining of chemically pure and otherwise satisfactory mirrors.

Using two wave-lengths, the optical constants and angles of principal incidence and principal azimuths for opaque films of various metals are determined, the results being set out in the following table, in which n is the refractive index, k the absorption coefficient, K the absorption index ($k = n$K), R the reflection coefficient, $\overline{\phi}$ the angle of principal incidence, and $\overline{\psi}$ the principal azimuth.

$\lambda = 5780$ Å.U.

Metal.	n.	k.	K.	R %.	$\overline{\phi}$	$\overline{\psi}$
Silver	0·172	3·34	19·30	94·5	74·5°	43·5°
Gold	0·302	2·70	8·93	86·5	71·7°	42·15°
Platinum	1·920	4·05	2·10	69·2	77·9°	32·8°
Copper	0·515	2·53	4·91	76·3	70·95°	39·9°
Nickel	1·840	2·97	1·61	56·5	74·85°	30·1°
$\lambda = 5460$ Å.U.						
Silver	0·168	3·14	19·60	94·0	73·7°	43·6°
Gold	0·446	2·39	5·36	77·2	70·1°	40·4°
Platinum	1·830	3·85	2·09	67·9	77·9°	32·8°
Copper	0·901	2·43	2·70	62·2	70·9°	35·95°
Nickel	1·810	2·85	1·57	54·9	72·6°	29·8°

For different degrees of purity a functional relation is found to hold between the constants and between the angles of principal incidence, the purest layer showing the smallest refractive index. It is further established that the absorption coefficient k and the angle $\overline{\phi}$ are characteristic of the closeness of packing of the particles in the layer, and that the values of the constants corresponding to the highest k approximate closely to the values for metals in bulk. Those layers having different values of n for the same k are to be regarded as anisotropic. They satisfy the equations holding for double refraction as produced by an arrangement of rods, and the difference of their values is thus to be attributed to a varying orientation of the axes of particles in the layer. G. A. S.

1756. *Range of Measurements with Refractometers.* **G. Haenzel.** (Zeits. techn. Physik, 5. 4. pp. 140–141, 1924.)—An expression for k, the range of measurement of refractive indices by means of the Pulfrich refractometer, is derived in the form $\cos \phi = k/2c$, ϕ denoting the angle of the prism employed and c the limiting value of the sine of the angle of emergence of the ray from the prism on either side of the normal to the prism face. Values of the refractive indices of pairs of prisms for the continuous measurement of the refractive indices of liquids commencing at 1·3 are tabulated for values of k equal to 0·1, 0·2 and 0·3, and for values of c equal to 0·1, 0·2, 0·3, 0·5 and 0·7. Curves are drawn in which abscissæ represent values of k, whilst ordinates represent limiting values of c for values of the refractive index of the prism ranging from 1·5 to 1·9. [See Abstract 1118 (1922).] J. S. G. T.

1757. *Measurement of Refractive Index of Large Discs of Glass.* **J. Barot.** (Rev. d'Optique, 2. pp. 502–505, Dec., 1923.)—The author describes a method devised for measuring the refractive index of a large glass disc, such as that prepared for a large astronomical objective. For precise calculation it is necessary to determine the refractive index of the actual piece of glass used, and it is not sufficient to take the index found for another portion of the same melt. Two plane faces are ground on the edge of the disc at suitable points, the angle between these faces being as nearly as possible 60°. The exact angle of the prism thus formed and the angle of minimum deviation are measured by comparison with the corresponding angles of a reference prism previously measured. This prism is taken from the same melt as the disc to be measured, so that the differences involved are small. The special form of goniometer employed is described in the paper. J. W. T. W.

1758. *Changes in Refractivity produced by Ultra-violet Light.* **H. G. Smith.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 63–69, 1923.)—Owing to modifications produced in the molecules, the refractivities of certain gases should be different under the influence of ultra-violet light from what they are in the normal case. To test this a tube containing hydrogen, nitrogen and mercury vapour in turn is placed in one path of a Jamin interforometer and the fringe movement consequent on shutting off ultra-violet rays which had been exciting the gas for a given time noted. Results are given showing increases in refractivity of hydrogen and nirtogen on shutting off the rays; this seems to indicate dissociation into atoms. Mercury most often showed a decrease, possibly owing to the formation of a diatomic molecule. Rough figures are given for the life of atomic hydrogen and nitrogen under the given conditions. G. A. S.

1759. *Dispersion of Light by Irregular Refraction and by Molecular Scattering.* **J. Spijkerboer.** (K. Akad. Amsterdam, Proc. 27. 1–2. pp. 165–173, 1924.)—The effect of the mutual influence of molecular scattering and scattering by irregular refraction upon the dispersion of light in the photosphere of the sun is investigated mathematically. It is shown that each kind of scattering contributes to the economical consumption of energy available within the solar nucleus, this energy being emitted at a slower rate than would be the case in the absence of scattering. In an atmosphere comprising regions where molecular scattering occurs, and in which the density varies irregularly, the effect of irregular refraction upon the distribution of radiation in different directions and on the intensity of the emitted radiation is less marked the greater the depth at which the scattering region occurs within the atmosphere. J. S. G. T.

1760. *Twyman's Interferometer.* **K. Butkow.** (Zeits. f. Physik, 22. 6. pp. 384–396, 1924.)—Discussion of the application of Twyman's interferometer [Abstract 830 (1923)] to the estimation of aberrations of the third order in optical systems. The topics worked out are the form of the waves; spherical aberration in general; spherical and chromatic aberration in a photographic lens; the same in a telescope; coma; astigmatism; curvature of the image. A. D.

1761. *The Optics of the Nervous System.* **L. T. Troland.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 389–409, March, 1924.) —Presidential address to the Optical Society of America.

1762. *Vision and the Technique of Art.* **A. Ames, Jr., C. A. Proctor** and **B. Ames.** (Am. Acad., Proc. 58. pp. 3–47, Feb., 1923.)—This paper is divided into seven chapters, and deals with pictorial effects rather than with optics. Subjects to which particular attention is paid are aberration, depth of field, distortion, sensitivity of the retina, and binocular vision. The paper is profusely illustrated in order to show the characteristics of the images formed by the lens system of the human eye. The authors call attention to monocular depth, and point out that this may be due to chromatic aberration. W. R. C.

1763. *The Contemporary Position as regards Experimental Technique in Photochemistry.* **J. Plotnikow.** (Zeits. techn. Physik, 5. 4. pp. 113–125, 1924.)—Apparatus available for photochemical investigations—*viz.*, radiation sources and thermostats, apparatus for the measurement of radiant energy and for the determination of the Schwarzschild constant of a photographic plate, light filters—is briefly reviewed and critically discussed. J. S. G. T.

1764. *The Mesomorphic State and Magnetic Double Refraction.* **L. Royer.** (Comptes Rendus, 178. pp. 1066–1068, March 24, 1924.)—The optical behaviour of mesomorphic bodies is explained by analogy with magnetic double refraction [see Abstract 809 (1910)]. Langevin's laws are applied [Abstract 1423 (1910)] and verified by means of Dorn and Lohmann's data for ethyl ethoxybenzalamino-α-methylcinnamate [Abstract 1397 (1909)]. Havelock's law of dispersion is not always accurately obeyed by mesomorphic bodies, but with rise of temperature the double refraction decreases, as in the magnetic effect. From these resemblances it is concluded that the mesomorphic state is due to a spontaneous mutual orientation of the molecules caused by a molecular field. G. E. A.

1765. *Photographic Photometry in the Ultra-violet.* **G. R. Harrison** and **C. E. Hesthal.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 471–485, March, 1924.)—The difficulties and advantages of photographic photometry in the ultra-violet are briefly discussed, and details given of the photographic characteristics of a commercial panchromatic film exposed to radiation of wave-length 4880–2100 Å. and developed with elon-hydrochinon. The results obtained indicate that as the wave-length of the radiation decreases from the visible region, provided the rate of influx of light energy remains great enough, the contrast does not measurably decrease until a wave-length equal to about 2600 Å. is reached. The contrast falls to a very low value at 2350 Å., and then increases, attaining a value equal to that in the visible region of the spectrum at about 2144 Å. The speed of the emulsion decreases rapidly with decrease of wave-length, the decrease being very rapid below 2400 Å. The length of the straight portion of the characteristic curve of the plate varies more with the rate of energy input than with wave-length, although, on the whole, the scale is less in the ultra-violet. The value of p in Schwarzschild's relation $d = \gamma \log It^{p} - c$ [Abstract 815 (1900)] is found to be not a constant. Self-reversal does not set in so rapidly in the ultra-violet as has been supposed, provided sufficient intensity is available. For equal intensities in the visible and ultra-violet regions, self-reversal sets in at lower densities in the latter case. A panchromatic film bathed with "Nujol" has its opacity/exposure ratio at 2144 Å. increased 225 times compared with that of normal film for high intensities of light. This greater sensitivity is attributable to a greater threshold sensitivity and speed. At 2400 Å. bathing the film increases both contrast and speed, with the result that the sensitivity is increased four times only. Very little effect is produced above 2500 Å. J. S. G. T.

1766. *The Laws of Blackening of Photographic Plates.* **H. Buisson and C. Fabry.** (Rev. d'Optique, 3. pp. 1–27, Jan., 1924.)—The object of the article is to give an exposition of the laws governing the densities of photographic plates and to establish some new properties of these plates. Having defined the density which characterises the blackening of the plate, the authors describe the apparatus used to measure the densities, such as opacity-meters and microphotometers. The Hartmann microphotometer is described in some detail, and also a photometric apparatus by Jobin. A brief reference is made to the subject of sensitometers. The question of the darkening of the plate as a function of the intensity of the active light and of the time of exposure is also investigated. The results obtained indicate that there is a very marked influence of the active radiation on the law of darkening, the factor of development (*gamma*) being able to vary from 3 to 1 when there is a variation of radiation from the visible spectrum to an ultra-violet one in the region of 2500. A theory is put forward to account for this large variation. The article is concluded by a sketch of the photometric methods used in photography and of the conditions in which these methods have given numerical values having a definite signification. A. W. J.

1767. *Generalised Meridional and Sagittal Formulæ.* **E. D. Roe.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 461–470, March, 1924.)—A mathematical deduction, from first principles, of the formulæ giving the path of a ray travelling from one homogeneous medium into a second, the bounding surfaces between the media being of any form whatever. The results obtained are compared with those deduced by Heath (Geometrical Optics, 2nd ed., 1895. pp. 180 *et seq.*), which the author considers to be lacking in rigour and consistency. The treatment is essentially mathematical and cannot be conveniently abstracted.

J. W. T. W.

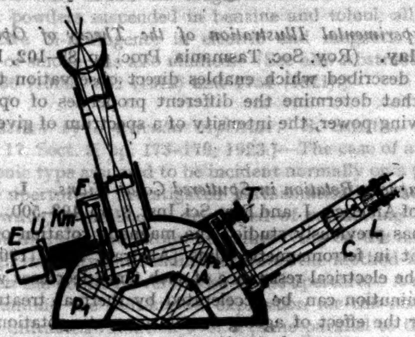
1768. *Influence of Defects in Uniformity of Photographic Plates upon Photometric Measurements.* **(Miss) Clavier.** (Bull. Astronomique, 3. No. 2. pp. 341–359, 1923.)—Photography has come more and more into general use in scientific research, but the method is open to serious criticism. The photographic plate does not register accurately; it possesses defects of uniformity which limit the precision obtainable in measurements of photographic photometry. When a plate is acted upon by a uniform light, differences in densities are found at different points, often greater than errors able to affect the measurement itself. In the present paper a number of plates are examined photometrically in order that the errors due to the non-homogeneity of the photographic plates may be discovered and the means of correcting these found. The inequalities may be due to the emulsion, to its support or to development; these points are discussed. It is found that the precision of the measurements in photographic photometry is limited by the plate itself, and certain methods of removing much of the disability are described. A. E. G.

1769. *Equi-altitude Measurement by Photography.* **R. Baillaud.** (Rev. d'Optique, 3. pp. 71–79, Feb., 1924.)—An astrolabe with a large prism is provided with means for photographing the two images of a star. The image lines traced out by the star are interrupted at every alternate second by a screen which is operated electrically by means of a clock. The exact time of coincidence of the images may therefore be determined without any personal error of the observer. The construction of this screen system, and of the double bath of mercury used as an horizon free from vibration, is described in the paper. J. W. T. W.

1770. *Multiple Photographic Objective with reduced Stereoscopic Effect.* **J. Thovert.** (Rev. d'Optique, 3. pp. 80–82, Feb., 1924.)—Trichromatic photography by means of three juxtaposed objectives possesses the disadvantage that the stereoscopic effect interferes with the accurate superposition of the images, especially when the object photographed possesses considerable depth. The device of forming a real image, by means of a single lens, on a diffusing surface, and then taking a triple photograph of this image, is inconvenient on account of the loss of light involved. The author describes a device in which a virtual image of the object is formed by a diverging lens placed in front of the multiple photographic lens. This virtual image possesses a much reduced depth, with a corresponding reduction in the stereoscopic effect produced in the final photographs. J. W. T. W.

1771. *Optical Pyrometer as a Brightness Photometer.* **W. E. Forsythe.** (Frank. Inst., J. 197. pp. 517–525, April, 1924.)—The optical pyrometer is essentially a brightness photometer, the comparison being made only for those wave-lengths lying within the restricted region of the spectrum transmitted by the pyrometer filter. It is thus readily adaptable to photometry by the Crova method. The author describes experiments made with a special filter consisting of two pieces of unsaturated green and a piece of Corning high-transmission red. This combination has a very narrow band of transmission in the region $0 \cdot 57$ to $0 \cdot 58\,\mu$. A table is given to show the results obtained by various observers in measuring with this screen, in a disappearing filament pyrometer, the brightness of a white surface illuminated by means of a gas-filled lamp. The readings were in much closer agreement by this method than when the same measurement was made by the same observers using an ordinary photometer. J. W. T. W.

1772. *Glitter and its Measurement.* **H. Schulz.** (Zeits. techn. Physik, 5. 4. pp. 135–140, 1924.)—The dependence of the glitter of a surface upon the ratio of the light regularly reflected to that diffusely scattered by the surface is briefly discussed, and an apparatus by the use of which this ratio may be determined is described. Light from the small glow-lamp L passes through the condenser C and falls upon the surface to be investigated. Light is regularly reflected to the prism P_1, and thence to the photometric comparison prism P_3. Scattered light is reflected by the prism P_2 to P_3. The two halves of the prism P_3 are observed in an eye-piece as shown. A is a compensating plate for eliminating any initial softening of the scattered light. The two beams are adjusted to equality, as viewed in the eye-piece, by suitable adjustment of the wedge K*m*, which is turned by the handle E. The position of the wedge relative to the reflected beam is read on a scale visible on the window F. Light filters separating out radiation of approximate mean wave-lengths 630, 580, 530 and 480 $\mu\mu$ respectively may be inserted in the incident beam from L by suitable adjustment of T. The scale of the instrument is extended by inserting an absorbing wedge, rotated into position by means of U, in the regularly reflected beam. Precautions necessary in the use of the instrument are briefly discussed. J. S. G. T.



1773. *Measurement of Daylight Factor.* **A. K. Taylor.** (Journ. Sci. Instruments, I. pp. 214–218, April, 1924.)—A portable instrument is described for the direct measurement of the daylight factor at any place. A test card is placed in the given position, and a disc of the same colour and reflection ratio is suitably illuminated by direct skylight passing through an iris diaphragm. The size of the diaphragm is altered until the brightness of the disc is equal to that of the test card, when the daylight factor can be read off directly. The scale calibration can be deduced from theory or determined by experiment; the range can be altered by the use of neutral filters. G. A. S.

1774. *Nodal Slide Modification.* **T. Smith.** (Journ. Sci. Instruments, 1. pp. 209–213, April, 1924.)—In its ordinary form the nodal slide can be used only when the light waves incident on the lens are sensibly plane. It can be made available for cases where the incident light is divergent by introducing between object and lens a Galilean telescope which is made to undergo the same longitudinal movements as the point of the image momentarily being examined. Applications to photographic and interferometric methods of examination are given. G. A. S.

1775. *New Flicker Photometer for Heterochromatic Photometry.* **J. Guild.** (Journ. Sci. Instruments, 1. pp. 182–189, March, 1924.)—The bench flicker photometer, the construction, maintenance and use of which is described in the present article, was designed in the Optics Department of the National Physical Laboratory. The instrument satisfies the conditions found by H. E. Ives in order that a flicker photometer may measure true brightness, and has the advantage over the attachment designed by E. F. Kingsbury for converting an ordinary Lummer-Brodhun photometer into a flicker photometer that no optical parts intervene between the eye and the screens, thus allowing the lamps to be as far from the instrument as possible in view of the high illumination required. M. A. G.

1776. *Experimental Illustration of the Theory of Optical Gratings.* **A. L. McAulay.** (Roy. Soc. Tasmania, Proc. pp. 87–102, 1923.)—Simple apparatus is described which enables direct observation to be made of the factors that determine the different properties of optical gratings, such as resolving power, the intensity of a spectrum of given order, etc. G. A. S.

1777. *Magnetic Rotation in Sputtered Cobalt Films.* **L. R. Ingersoll.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 493–500, April, 1924.)—The author has previously studied the magnetic rotation of the plane of polarised light in ferromagnetic films [Abstract 1534 (1909)], and it is known that the electrical resistance of such films decreases with time, and that this diminution can be accelerated by thermal treatment. In the present paper the effect of ageing on the magnetic rotation of the plane of polarisation in sputtered Co films has been investigated. The films were prepared in a special chamber, which allowed the film to be kept cool during the process of sputtering. The rotation measurements were made over a range of wave-lengths $0\cdot6$ to $2\cdot3\,\mu$, both for the Faraday and Kerr effects. The thermal treatment consisted in maintaining the films for various periods of time (up to 40 hours) at different temperatures (up to 340° C) in an atmosphere of low pressure H. As regards both transmission and reflection effects this thermal treatment caused only a small increase of the rotation in the region of the visible spectrum, but the increase became very much larger as the range of longer wave-lengths was approached (as much as 10 times for $2\,\mu$). If the heat treatment coalesces the granules of which the film is composed into larger units, it would appear that the magnetic rotation is dependent on the size and character of the particles, and cannot be regarded as a molecular or atomic property. This view is apparently confirmed by two further experiments: (1) on colloidal iron in isobutyl alcohol, which showed no rotation above that of the alcohol itself, although the iron particles were strongly magnetic; (2) on a sputtered film of Ni, which showed no rotatory effect until subjected to heat treatment. L. L.

1778. *Electric and Magnetic Double Refraction of Suspensions.* **S. Procopiu.** (Ann. de Physique, 1. Ser. 10. pp. 213–292, March–April, 1924.)—Liquids which hold solid particles in suspension may become bi-refringent, but their properties are not the same as those of pure liquids.

The bi-refringence is brought out by relatively weak fields, and tends rapidly to a saturation value; it is also accompanied by dichroism, *i.e.* an unequal absorption of the light for vibrations parallel and perpendicular to the direction of the applied field. The author used a quarter-wave plate in conjunction with a Laurent analyser (Senarmont-Chauvin method) to detect and measure the double refraction, monochromatic light of various wave-lengths being obtained by means of filters and a half-watt lamp. "Mixed liquors" are formed from insulating liquids and powdered uniaxial crystals. When a crystal is associated with a liquid of the same index as the mean index of the crystal, the electric double refraction is positive, *i.e.* the extraordinary index for vibrations parallel to the field lines is greater than the ordinary index for vibrations perpendicular to the field; zirconium is an exception to this statement. Analogous results were found for magnetic double refraction. In the case of metallic powders suspended in benzine and toluol, all the liquors exhibited negative bi-refringence in electric and magnetic fields. The optical activity of smoke was also studied. [See also Abstracts 55 (1903), 2059 (1907), 1530 (1909), 662 (1912) and 1751 (1921).] G. E. A.

1779. *Diffraction by a Circular Aperture.* **S. Smith.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 173–179, 1923.)—The case of a plane wave of simple harmonic type assumed to be incident normally on a plane screen with a circular aperture is investigated mathematically. As limited to a longitudinal wave, a method is developed of calculating the relative intensities of the diffracted radiation at points lying on the normal to the aperture through its centre, the main feature of the method being that it can be used when the points lie very close to the aperture. A new method is given for obtaining the well-known expression for the distribution of intensity of the diffracted radiation over a plane parallel to the aperture, but very distant from it. A. B. C. L.

1780. *Scattering of Light by Liquids: Effect of Direction on Polarisation and Intensity.* **W. H. Martin.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 151–155, 1923.)—In Rayleigh's investigation [see Abstract 1655 (1899)] of the variation of the intensity and polarisation of the light scattered by any medium with the direction in which the scattered light is observed is limited to the particular case in which the light scattered in a direction normal to the direction of propagation of the incident light is completely plane-polarised. Experiment having shown that for dust-free gases and liquids the scattered light is not completely plane-polarised, the effect is considered of this defect in polarisation on the distribution of the light scattered in various directions. The investigation is carried out on the lines of that pursued by Rayleigh, with the limitation that for liquids the electric field within any molecule must be considered as being greatly affected by the neighbouring molecules. Experimental checks by Lehrman, showing satisfactory agreement with calculated results, are quoted. A. B. C. L.

1781. *Dispersity of Silver Halides in Relation to their Photographic Behaviour.* **F. E. E. Germann** and **M. C. Hylan.** (J. Phys. Chem. 28. pp. 449–456, May, 1924.)—A brief *résumé* is given of the results of the work of various authorities on the relation between the size of the silver halide grain and the speed of the photographic plate. The authors first consider the subject from a purely theoretical standpoint, and then describe experiments made with the object of testing their conclusions. It is shown that from purely theoretical considerations small-grained photographic emulsions should be faster than large-grained ones; the apparent variations from this rule are explained on the basis of adsorption of the silver halide. Adsorption phenomena being more accentuated in silver iodide than in silver halides, a study of emulsions of this material was undertaken by the authors. Both large- and small-grained emulsion preparation methods are described. It was found that among unsensitised emulsions the ones containing the larger grains were the faster, whilst in the case of sensitised emulsions the ones containing the smaller grains were found to be the faster. It was concluded that, in ordinary photographic emulsions, owing to adsorbed impurities, it is impossible to formulate any relationship between grain size and sensitiveness, but that among emulsions free from adsorbed retarders the ones containing the smaller grains are the faster. A. W. J.

1782. *The Dispersion of Light in Gaseous Bodies within the Ultra-violet Spectrum. Part IV.* **J. Koch.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 18. No. 3. pp. 1–15, 1924. In German.)—The present paper is a continuation of previous work published in the above journal in 1912, 1913 and 1914. It commences with a description of Drude's dispersion theory and the later work of Natanson, Debye, and Sommerfeld. Following this comes an account of the author's experimental method, which is an extension and amplification of the trustworthy Jamin refractometer method. By suitable arrangements the whole course of the dispersion could be accurately followed with only two spectral photographs. In the three previous papers the dispersion of light has been measured in hydrogen, atmospheric air, nitrogen, helium, carbon monoxide and carbon dioxide, and this work has now been extended to nitrous and nitric oxides by an improved experimental installation now to hand. The previous work showed that, with the exception of helium, the simple Cauchy dispersion formula does not give accurately enough the course of the dispersion in the extended region. Especially great are the deviations in cases where a strong ultra-violet absorption occurs as shown for carbon monoxide. With nitric oxide a strong absorption was found by Kreusler at about 2000 Å.U., and from the dispersion data now obtained the simple Cauchy formula is found insufficient, showing that from the standpoint of the classical theory the assumption of only one ultra-violet fundamental period does not explain the whole dispersion range. The absorption rises with extraordinary rapidity at the end of the quartz violet. The data for nitrous oxide deviate much less from the Cauchy formula than is the case for nitric oxide, and accompanying this circumstance is the greater transparency for ultra-violet light. Methods of preparation of the two gases are described, and complete tables of data are included. The paper concludes with a general discussion of the problem relating to dispersion and the molecular structure of matter.

H. H. Ho.

1783. *The Theories of Luminous Waves and Carnot's Principle.* **H. Chipart.** (Comptes Rendus, 178. pp. 1156–1158, March 31, 1924.)—Sarrau was of the opinion that the system of equations expressing his theory, $\partial^2 D/\partial t^2 = \Delta E + \text{grad. div. } E$, $E = f_1(D\partial D/\partial x, \partial D/\partial y, \partial D/\partial z)$, could afford an explanation of the phenomena of crystalline absorption. He states that the ordinary plane wave parallel to the axis is generally evanescent, and the extraordinary plane wave may be propagated without being impaired. The ordinary plane wave may cease to decrease when parallel to the principal axis and perpendicular to one of the three planes of symmetry in a crystal of the ternary system. The present author criticises the above statement as the result of a mistake by Sarrau, since, instead of being evanescent, the waves exhibit a disymmetry of propagation incompatible with Carnot's principle. This is mathematically demonstrated by the author, who establishes the reality of the roots of the velocity equation furnished by the electromagnetic theory. H. H. Ho.

1784. *Duration of Light Emission from Atoms and the Damping of Spectral Lines. Part III.* **W. Wien.** (Ann. d. Physik, 73. 7–8. pp. 483–504, March, 1924.)—Further measurements have been made of the damping constants of spectral lines. The arrangement of apparatus employed was the same as that used in the earlier work [Abstract 901 (1922)], but higher discharge potentials in the canal ray tube were used. Measurements were made for various lines of helium, mercury and hydrogen. The results finally obtained for the damping constant $2a$ were as follows: H_α, $5\cdot40\times10^7$; H_β, $5\cdot40\times10^7$; He ($\lambda447\cdot85$ $\mu\mu$, principal series), $5\cdot42\times10^7$; Hg ($\lambda435\cdot83$ $\mu\mu$, second subordinate series), $5\cdot5\times10^7$; Hg ($\lambda253\cdot6$ $\mu\mu$), $1\cdot02\times10^7$. The theoretical value given by the classical theory for H_α is $5\cdot35\times10^7$. A discussion is given of two methods for photometric measurements in the ultra-violet, (1) measurements of photoelectric currents, and (2) photographic method. The latter is the more sensitive. Special experiments were carried out to determine the absorption index. A. W.

1785. *Interferential Methods of Determining the Duration and Law of Emission of Light by Atoms.* **E. Bauer.** (Comptes Rendus, 178. pp. 1268–1270, April 7, 1924.)—According to the electromagnetic theory of Lorentz, the light emitted by electrons vibrating in the atoms is constituted by trains of damped periodic waves. This theory has been replaced by the hypothesis of quanta, which give us a relation between the frequency and total energy of a train of elementary waves, but gives no information upon the phenomenon of emission itself. In 1919 W. Wien [see Abstract 379 (1920)] thought to attain the latter by measurement of the luminous intensity at different points of a beam of canal rays in a perfect vacuum. This intensity diminishes starting from the kathode according to a law almost exponential. Wien deduced from these experiments the decrement of the luminous oscillations, of which the value is very nearly that foreseen by the classic theory. It is pointed out that the experiments of Wien did not give the required information about the elementary phenomenon. Methods of tackling this problem are discussed, and it is proposed to continue along experimental lines, commencing with ultraviolet rays of mercury excited by resonance. A. E. G.

1786. *The Mechanism of Luminous Emission in the Simplest Conditions.* **L. Dunoyer.** (Comptes Rendus, 178. pp. 1475–1478, April 28, 1924.)—E. Bauer has recently (see preceding Abstract) described some experiments which he is undertaking relative to the damping of luminous emission centres by means of a gas of one dimension. In that paper Bauer made certain references to the present author, and this paper is intended to make the position of the latter clear. An experimental method is here described, which it is pointed out was used in 1914 and is analogous to that which Wien used in 1919 with canal rays. It would thus appear incorrect for Bauer to consider the experiments of Wien as the first attempt to attain by direct experiment the damping of centres of luminous emission. A. E. G.

1787. *Triboluminescence Spectra.* **C. S. Beals.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 125–129, 1923.)—Pieces of manganese, cerium, quartz, and wurzite of circular cross-section were mounted on the shaft of an electric motor in turn, and the triboluminescent spectra excited by pressing a piece of steel or carborundum against them (and in the case of quartz, another piece of quartz). As a result, two types of triboluminescence may be distinguished. The two metals gave a continuous spectrum, and in addition a few lines occurring in the arc spectrum of the metal. No luminescence could be induced under water. It was therefore concluded that oxidation was the main cause of the phenomenon. On the other hand, the quartz and wurzite gave continuous spectra only, and this could also be produced under water. From this it was deduced that with crystals the power of giving luminescence is an intrinsic property of the crystal, and is independent of the surrounding medium. [See also Abstract 2274 (1922).] A. C. M.

1788. *Intensity Relations in the Helium Spectrum.* **C. B. Bazzoni** and **J. T. Lay.** (Phys. Rev. 23. pp. 327–336, March, 1924.)—Inside a blown quartz tube, electrons from a tungsten spiral were accelerated into the equipotential space inside a hollow copper anode. Unusual purity was obtained by heating the anode red-hot by high-frequency induction to remove gases, in addition to other precautions. *The minimum operating potential* was found to be 21·5 volts, just above the resonance potential. The relative importance of the ionisations at 20·5 and at 25·5 volts depends on the pressure and current density; after the current has risen to a high value the 25·5 point is obscured, indicating probably a decrease in the proportion of normal atoms under the increased radiation. *The change in relative intensity of arc spectrum lines with voltage* was studied for 25 to 85 volts, using the neutral wedge method of Nicholson and Merton. The crossed orbit lines λ4437 (1P – 4S), λ4387 (1P – 4D), λ4922 (1P – 3D), λ5016 (1S – 2P) all increase with voltage, though not uniformly, while the co-planar lines λ4713 ($1\pi - 3\sigma$), λ5875 ($1\pi - 2\delta$), λ4471 ($1\pi - 3\delta$) all diminish to a minimum at about 50 volts. AUTHOR.

1789. *Excitation of the Helium Spectrum by Electronic Bombardment.* **A. Udden** and **J. C. Jacobsen.** (Phys. Rev. 23. pp. 322–326, March, 1924.)—*Ortho- and Parhelium Spectra with the Energy of the Exciting Electrons, 25 to 100 Volts.*—In the tubes used, electrons were accelerated from a Wehnelt cathode through a platinum grid 1 mm. away into a metal box, and the spectrum of the light produced inside the box was photographed. A pressure of about 1 mm. was used. At the higher voltages, the two spectra were of about equal intensity, but at low voltages the orthohelium spectra was relatively much the stronger. This is explained by supposing that the orthohelium spectrum is to a large extent due to bombardment of metastable atoms by electrons with energies corresponding to less than 5 volts. A special experiment, however, in which the helium was bombarded by both 5-volt and 21-volt electrons, gave a negative result, no additional light being excited by the slower electrons ; but this is not considered as conclusive. AUTHOR.

1790. *Modification of the Band 3064 of Oxygen in the Magnetic Field.* **R. Fortrat.** (J. de Physique et le Radium, 5. pp. 20–32, Jan., 1924.)—This band has already been analysed into its band-series by Heurlinger. He simplified it into two bands, each double and each consisting of the usual three branches, P, Q and R. The source was the oxy-acetylene flame, and it was observed perpendicularly to the lines of force. The modifications were greatest near the head of the band ; they were all asymmetrical, and could be divided into three classes—doubling, displacement, and asymmetrical widening. The possibility that these modifications are really the beginnings of simplifications is rejected, as first, the doublets are very widely separated, and so a very great sensitivity would have to be postulated, and secondly, instead of being drawn together by the field, they are driven apart. The actual modifications are given in detail ; they are too numerous to be abstracted. The results confirm Heurlinger's analysis. It is found that lines of the same band-series undergo modifications of the same nature, but different in extent. This law is only partially obeyed ; many important exceptions are found. The largest field used was 39,700 gauss. It is suggested that with still higher fields important simplifications might be effected. A. C. M.

1791. *Reversed Spectrum and Spectrum-Analysis.* **A. Kirschmann.** (Zeits. Instrumentenk. 44. pp. 173–175, April, 1924.)—Methods of producing reversed spectra have previously been given [see Abstract 945 (1917)]. By using a fine wire or hair as negative slit the characteristic lines of elements are seen as fine black lines upon a coloured background. Accurate settings can be made on such lines, especially in the case of faint flame spectra. The method has been tried with Geisler tubes, and is suggested for astronomical work. F. S.

1792. *Spectrographic Methods for the Ultra-violet.* **J. Duclaux** and **P. Jeantet.** (Rev. d'Optique, 2. pp. 384–391, Sept., 1923.)—The use of ordinary photographic plates for the ultra-violet as far as 1850 Å. is recommended, provided the plate has been smeared with a film of oil. Many lubricating oils are strongly fluorescent between 4700 Å. and 3700 Å., but better results have been obtained with colourless vaseline oil which fluoresces between 3800 Å. and 3200 Å. The thickness of film should be 0·003 mm., or about 1 drop per square decimetre. By this means exposures have been reduced to $\frac{1}{10}$ part at 1900 Å.

As dispersive medium a 70° hollow prism filled with water and provided with quartz cover-plates is advised, the reasons advanced being (1) water is homogeneous while quartz in general is not ; (2) larger prisms can be employed, as it is easier to get good plates of quartz than good blocks ; (3) dispersion beyond 2000 Å. is greater for water than for quartz ; (4) as the mean refractive index of water is less, a larger angle prism can be used to further increase the dispersion ; (5) the transparency of water is superior. The disadvantages are (1) the dispersion of water for longer waves than 3000 Å. is so small as to be useless ; (2) the variation of refractive index with temperature is forty times as great for water as for quartz, The latter has, however, given less trouble than would be expected. A number of reproductions of spark spectra to 1850 Å. are given. F. S.

1793. *Arc Spectra of Metals in Various Media and in Vacuo.* **S. Procopiu.** (Ann. de Physique, 1. Ser. 10. pp. 89–133, Jan.–Feb., 1924.) —Most previous work refers to the appearance of spark lines in metallic arcs, so that it is of interest to examine the variations of arc lines. Arcs of the metals Cu, Au, Mg, Ca, Zn, Cd, Hg, Al and Tl were studied in air, hydrogen, nitrogen, coal-gas, water and vacuum. An arc lamp with magnetic feed was used, and the spectra photographed with a Hilger quartz spectrograph. In water, coal-gas and hydrogen the arc lines are feeble, and most energy is transferred to the first few members of the various series, while many spark lines appear. Arc lines are also broadened. Lists are given of the lines and series which persist. In nitrogen, arc lines are stable, and the higher terms of series are emitted as well as *in vacuo*. Spark lines in this case are weakened. In this gas a number of arc lines are reversed. The effect of a Bunsen flame on the arc is similar to that of a vacuum, many spark lines being produced, and many arc lines reversed. It is possible to get some lines, such as the H and K lines of Ca, doubly reversed. The characteristic appearance of the arc in vacuum, especially in the case of the more fusible metals, such as Zn and Cd, consists of a bright white light round the cathode and a rosy glow round the anode. Two stable conditions occur according as to whether or not the anode penetrates the cathode light. The potential across the arc in the former case is considerably less than in the latter, and varies with the metal of the electrodes. The lines in vacuum are sufficiently sharp for interference measurements, and the higher terms of series are produced sufficiently intensely to be measured. Many lines, both arc and spark, are reversed. The appearance of arc and spark lines differs so much from that in air as to constitute a method of separation of the two categories of lines. For vacua higher than 1 mm. of mercury a continuous ultra-violet spectrum appears, more especially at the anode. It is established that material is transferred from the cathode to the anode. In the case of arcs formed between poles of different metals, the spectrum consists chiefly of lines belonging to the metal of the cathode. Spark lines are produced in greater number by introducing the oxide or a halogen salt of the metal into the arc. F. S.

1794. *A New Hydrocarbon Band.* **R. Fortrat.** (Comptes Rendus, 178. pp. 1272–1275, April 7, 1924.)—To the bands λ4320 and λ3889 are to be added a new band λ3143. It is shown to possess the customary three branches, P, Q and R. It has been observed in the blue cone of the hydrocarbon flame. A little confusion is caused by superposition with the oxygen band λ3064 emitted at the same time. The new band resembles the other two bands as much as they resemble each other, so that it is quite possible that it is emitted by the same molecule, but probably under different conditions. The value of the moment of inertia calculated from the band formula (which does not fit very well, so that mean values have to be employed) is in close agreement with that calculated from the other two bands. A. C. M.

1795. *Spectra of Isotopes.* **H. Nagaoka and Y. Sugiura.** (Nature, 113. pp. 632–534, April 12, 1924.)—Atoms, especially in the ionised state, may form pairs, and so give rise to non-series lines. Where isotopes are present, symmetrical and asymmetrical pairs may be formed. If two atoms are quasi-elastically connected and set in vibration, then the frequency will be $\sqrt{f}/\sqrt{\mu}$, where f is a constant depending on the connection and μ is the quotient of the product and sum of the masses. These vibrations have been quantised by Born and Hückel [Abstract 1527 (1923)]. As f will be electromagnetic in origin, it can be taken to be the same in the case of isotopes, and so one obtains for the difference in wave-length $d\lambda$ between two symmetric pairs

$$d\lambda = \left(1 - \sqrt{\frac{m_1}{m_2}}\right)\lambda_2;$$

and for symmetric and asymmetric pairs

$$d\lambda = \left(1 - \sqrt{\frac{m_1 + m_2}{2m_2}}\right)\lambda_2$$

and

$$d\lambda = \left(\sqrt{\frac{m_1 + m_2}{2m_1}} - 1\right)\lambda_1$$

where $m_1 < m_2$, and $\lambda_1 < \lambda_2$, λ_2 being the wave-length due to the heavier pair. Nine elements have so far been examined for the presence of these lines, and the coincidence is close, while a very large number of non-series lines are made to agree; *e.g.* out of 856 Ne lines examined, 498 are in agreement. It is suggested that the method may have great value in determining isotopic atomic weights and in gleaning information about the structure of the nucleus. A. C. M.

1796. *Spectra of Argon, Krypton and Xenon.* **G. Déjardin.** (Comptes Rendus, 178. pp. 1069–1071, March 24, 1924.)—An account of the excitation of the spectra of these elements in three successive stages, by increasing the velocity of ionising electrons in three and four electrode tubes. It is found that these stages are the same as are obtained by increasing the potential applied in the electrodeless discharge [see Abstract 1471 (1924)]. The present paper deals with xenon in particular. The critical potentials are determined by the study of the variations in ionisation current and electron current with variation of the accelerating potential. The first spectrum is observed when the potentials are greater than 15·2 volts for A, 12·7 volts for Kr, 10·9 volts for Xe. It is emitted by the neutral atom, and is therefore the arc spectrum. The second spectrum consists of three groups, excited by successively higher potentials; these correspond to the first, second and third spark spectra, or the types E_1, E_2, E_3, emitted in an electrodeless tube. E_1 is emitted when the potential is greater than one of two limits, depending upon the pressure and the electron current. These are: A 19 volts, 34 volts; Kr 15·5 volts, 28·25 volts; Xe 13 volts, 24·25 volts. The differences between these pairs of values are equal to the respective ionisation potentials. It is therefore suggested that the lower value is the ionisation potential of the monovalent ion, while the second is the potential required for simultaneous ejection of two elections from the neutral atom—a " double ionisation potential." The lines of the spectrum E_2 appear when a still higher threshold value of potential is passed. These values are: A 70 volts, Kr 59 volts, and Xe 51 volts. Lines probably belonging to a third spark spectrum are also obtained. The ratios of the double and single ionisation potentials and the ratios of the ionisation potentials of the second and first spark spectra are sensibly constant for all these elements. They are:—

A	2·24	4·61
Kr	2·22	4·65
Xe	2·22	4·68

A. C. M.

1797. *The Extreme Ultra-violet Spectrum of the Carbon Arc.* **W. W. Shaver.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 131–135, 1923.)—A spectrograph with fluorite prism and lenses was used, together with the arc lamp described by McLennan and Ainslie [Abstract 2409 (1922)]. The arc was operated with 8 amperes at 110 volts, and Schumann plates were used. Of the ten lines between 1930·61 and 1323·79 which were recorded in addition to those measured by Simeon [Abstract 1145 (1923)], three had been found by Millikan in the hot-spark spectrum, and one other, in addition to one of these three, had been observed by Wolff.

F. S.

1798. *Ultra-violet Line Spectrum of Chlorine.* **E. v. Angerer.** (Zeits. wiss. Phot. 22. pp. 200–209, Jan., 1924.)—An investigation of the spectrum of chlorine between the wave-lengths 2065 Å. and 3522 Å.U. Tables of the lines observed are given and compared with those obtained by Jevons [see Abstract 1855 (1923)]. In order to make impurities of less account a stream of chlorine was kept passing through the tube; the discharge was excited by a resonance arrangement, such that few but correspondingly powerful sparks were produced. It is suggested that some of the lines in Jevons' list are due to impurities. A Steinheil spectroscope having a dispersion of 15 Å. per mm. at 3000 Å. and 4·4 Å. at 2000 Å. was employed; the plates were Schumannised, and as standards the iron arc was used down to 2300 Å., and below that the spark between copper electrodes. Attention is directed by the author to a group of six lines between 2093 Å. and 2086 Å. which show symmetry [see Abstract 269 (1924)].

A. C. M.

1799. *Ultra-violet Spectrum of Chromium.* **A. B. McLay.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 137–139, 1923.)—The spark spectrum of chromium was photographed with a Hilger quartz spectrograph, a spark with one electrode of aluminium and one of zinc-cadmium alloy being used as comparison. A table of wave-lengths and relative intensities of 105 lines between 1826 and 2204 is given, the wave-lengths being reduced to the international scale and to vacuum.

F. S.

1800. *Ultra-violet Absorption Spectrum of Furfural.* **F. H. Getman.** (J. Phys. Chem. 28. pp. 397–401, April, 1924.)—By means of a Hilger quartz spectrograph and, as source of ultra-violet radiation, a condensed spark between two electrodes of ferro-vanadium and ferro-chromium respectively, the behaviour of furfural towards such radiation in both alcoholic and aqueous solutions has been studied. The results obtained are identical, within the limits of experimental error, with those described by Purvis [Abstract 63 (1911)]. The persistence with which furfural absorbs ultra-violet radiation is doubtless the cause of Hartley and Dobbie's failure to detect its selective as well as its general absorption [Chem. Soc., J. 73. p. 598 (1898)]. The instability of furfural, indicated by its tendency to polymerise, is also probably connected with its marked absorbing power for ultra-violet radiation. T. H. P.

1801. *Absorption Spectrum of Gelatin as a Function of the Hydrogen-Ion Concentration.* **H. P. Higley and J. H. Mathews.** (Am. Chem. Soc., J. 46. pp. 852–855, April, 1924.)—The absorption of light by gelatin sols is determined by a spectrophotometric method. The results are expressed as curves in which *p*H values are plotted against the wave-lengths of the absorption bands for definite fractions of light absorbed. The curves are of the same general shape, exhibiting maxima at 5·5 and 6·6 *p*H values, and minima at 4·69 and 7·65. These minima probably bear some relation to the iso-electric point of the sol, but it is not quite clear what interpretation should be placed upon them. B. W. C.

1802. *Width of Lines in the Hydrogen Spark Spectrum.* **(Miss) M. Hanot.** (Comptes Rendus, 178. pp. 1071–1073, March 24, 1924.)—An investigation of the effect of pressure on the width of the Balmer lines. Hemsalech [Abstract 1428 (1900)] showed that the lines which are broad ordinarily in the spark in hydrogen at atmospheric pressure can be rendered fine and sharp by the inclusion of sufficient inductance. It was therefore necessary to find first if the nature of the circuit (*i.e.* the period and damping of the discharge) were the cause rather than the pressure. The lines were examined with a Rowland grating, giving a dispersion in the region considered of 5·6 Å. per mm. The discharge was a spark about 1 mm. long in an atmosphere of hydrogen at a pressure of about 90 cm. of Hg. The period and damping were varied, using an inductance and a variable $CuSO_4$ resistance. The character of the discharge was observed in the rotating mirror. As a result it is shown that the distribution of intensity is independent of the character of the damping. But the widths of the lines were altered by changing the period of the circuit. As the period increased the width of the lines decreased, more rapidly for H_β than for H_α. It is suggested that this is really a disguised result of alteration of temperature or of pressure. The initial value of the current depends on the ratio $\sqrt{c}/\sqrt{L}$, and so the insertion of the inductance diminishes the instantaneous rise of temperature and pressure at the first passage of the spark. A. C. M.

1803. *Secondary Standards of Wave-length from the New International Iron Arc.* **W. F. Meggers, C. C. Kiess and K. Burns.** (Bureau of Standards, Sci. Papers, No. 478. pp. 263–272, 1924.)—Certain lines, grouped as *c* and *d* lines because of sensitiveness to pressure, appeared to be displaced relative to *a* and *b* lines, so that in 1922 the International Astronomical Union recommended that light be taken from a central zone 1–1·5 mm. wide in a 12–15-mm. arc instead of from one 2 mm. wide in a 6-mm. arc. A new arc lamp is described to achieve the new conditions. Measurements were made with interferometer plates with silver and nickel films, and spectra photographed with the stigmatic concave grating mounting. A cadmium spectrum tube was used as source for the primary standard, and neon tubes for some comparison exposures. Results are given for 159 lines between 3370 Å. and 6678 Å., including 84 of the international secondary standards. For 23 lines of groups *c* and *d* the new values average 0·0072 Å. less than the secondary standards. Also 44 lines of groups *a* and *b* average 0·0029 Å. less than international values. The reason for the latter divergence is not obvious, but it may be due to a real error in the international system, which, it is pointed out, was not established strictly according to the logical definitions of such a system nor with the accuracy which might be possible now in a redetermination. F. S.

1804. *Infra-red Absorption of Hydrogen Cyanide.* **E. F. Barker.** (Phys. Rev. 23. pp. 200–204, Feb., 1924.)—The similarity of chemical behaviour of CN to that of Cl, together with the fact that the ionisation potential of HCN is in line with that of HCl, suggests that HCN may possess a simple vibration-rotation spectrum and a small molecular moment of inertia [see Abstract 1140 (1922)]. Kratzer classes the four infra-red bands together as a fundamental and successive harmonics. The three bands of lowest wave-length are now re-examined, and it is shown that the two bands of highest frequency are improbably the second and third harmonics of the maximum at 14 μ. The estimates of the moment of inertia from the different bands do not agree. The measurements of the band at 7 μ give a value about five times that of HCl, *i.e.* $13 \cdot 2 \times 10^{-40}$. A. C. M.

1805. *Interferometer Measurements of Longer Wave-lengths in the Iron Arc Spectrum.* **W. F. Meggers** and **C. C. Kiess.** (Bureau of Standards, Sci. Papers, No. 479. pp. 273–280, 1924.)—The international system of secondary standards extends to 6750 Å. in the red, but no extensive interferometer comparisons have been made between the primary standard and longer wave-lengths of iron. New values are given for 161 lines between 5534·525 Å. and 8824·238 Å., of which 75 are longer than 6750 Å. The probable error of each value is of the order of 0·001 Å. In the region in which these determinations overlap the secondary standards there is a systematic deviation indicating, that the accepted international scale is nearly 1 part in 1,000,000 too large. Comparison of these values with relative ones by Burns shows good agreement if the latter are adjusted to the new scale of absolute values. F. S.

1806. *Series of Triplets in the Arc Spectrum of Mercury.* **H. Buisson.** (Comptes Rendus, 178. pp. 1270–1272, April 7, 1924.)—In each of the sharp and the diffuse series the numbers of the first components known is large, while at present only a few of the second and third components are known. The author has now extended the number of complete triplets by photographing with a quartz spectrograph the light from a mercury vapour lamp through which a weak current was passing. The law of constant separations is upheld. A. C. M.

1807. *Isotopes of Mercury and Bismuth revealed in the Satellites of their Spectral Lines.* **H. Nagaoka, Y. Sugiura** and **T. Mishima.** (Nature, 113. pp. 459–460, March 29, 1924.)—By means of special experimental arrangements, high resolution is obtained in the ultra-violet spectra, and the structure of many hitherto unexplored lines is minutely examined. Typical examples are given showing apparently complex structure, the analysis being simplified by the consideration that both Hg and Bi are near the radio-active elements, so that the nuclei are probably approaching a metastable state. The K-radiation shows a small anomaly on passing from Au to Hg and from Pb to Bi; and the remarkable resemblance of non-series lines in Au and Hg indicates that, in spite of the unit difference in the atomic number, the nuclei may have something in common. The simple assumption is that a H-proton is slightly detached from the central nucleus and quasi-elastically connected with it, so that when excited by electromagnetic waves they make coupled vibrations. A table is given showing the number of satellites observed and the groups which can be obtained by their combinations, from which it is concluded that the satellites in Hg and Bi lines are due to different isotopes.

A. B. C. L.

1808. *Lyman Lines in the Neon Spectrum.* **K. W. Meissner.** (Ann. d. Physik, 73. 7–8. pp. 643–646, March, 1924.)—Lyman ghost-lines (Abstract 794 (1901), Phys. Rev. 16. p. 257, 1903) found in the infra-red spectrum of neon. The fundamental line is in the visible spectrum. [See Abstract 750 (1919)].

A. D.

1809. *Stellar Temperatures and the Absorption Lines of Silicon.* **C. H. Payne.** (Harvard Coll. Obs. Circ. 252. pp. 1–12, 1924.)—The intensities of lines due to silicon and to singly, doubly and trebly charged silicon have been determined by estimates from objective prism spectra. The maximum intensity of the lines from the differently charged atoms occur at G5, A0, B2 and O*e*. The observed intensity curves agree well with curves depending on the theory of Fowler and Milne. It is possible to construct a silicon temperature scale which differs considerably from that deduced from helium, and indicates even higher temperatures among the hotter stars.

A. Wh.

1810. *A New X-Ray Goniometer.* **K. Weissenberg.** (Zeits. f. Physik, 23. 3–4. pp. 229–238, 1924.)—Describes and illustrates a mechanically coupled arrangement of crystal and photographic plates to permit rotation of the crystal and simultaneous experimental determination of two reflexions. Thereby the angles between the lattice planes of the crystal can be simultaneously determined, and grid constants, goniometric measurements and plane indices rapidly and accurately obtained. The theory of the method is considered, and the application of the apparatus to crystallographic measurements illustrated at length.

B. J. L.

1811. *A Corpuscular Quantum Theory of the Scattering of Polarised X-Rays.* **G. E. M. Jauncey.** (Phys. Rev. 23. pp. 313–317, March, 1924.)—The methods of a previous paper [Abstract No. 535 (1924)], which gave a corpuscular quantum theory of the scattering of unpolarised X-rays, are here applied to the scattering of polarised X-rays. A formula is derived for the intensity scattered in any direction, and from this an expression is obtained for the ratio of the intensity scattered in the direction of the electric vector to that scattered in a direction perpendicular both to the electric vector and to the primary beam. The intensity scattered in the direction of the electric vector is not zero as it should be on the classical theory. Taking the polarising angle as the angle of scattering which gives completely polarized rays from unpolarised primary rays, a formula is derived which shows that for very long wave-lengths the polarising angle is 90°, but for short wave-lengths it is less than 90°.

AUTHOR.

1812. *The Quantum Theory of the Fraunhofer Diffraction.* **P. S. Epstein** and **P. Ehrenfest.** (Nat. Acad. Sci., Proc. 10. pp. 133–139, April, 1924.)—Duane has recently [see Abstract 2430 (1923)] formulated a theory of the reflection of X-rays by crystals, based on quantum ideas without reference to interference laws. Compton, enlarging upon a hint in Duane's paper, has recently [Abstract 415 (1924)] pointed out that the latter's hypothesis can be justified by the application of the general rules of the theory of quanta to the translatory motions of a crystal lattice. Both these authors have dealt with the case of parallel beams of incident and reflected light (Fraunhofer diffraction) and of infinite lattices giving absolutely sharp pencils of reflected rays of different order. The purpose of the present paper is to study the problems with respect to finite gratings and other diffracting systems, again with restriction to the case of the Fraunhofer reflection. A finite grating can be regarded as a superposition of infinite gratings according to Fourier's theorem, and mathematically, therefore the problem is reduced to a Fourier analysis. A finite grating also produces a more or less continuous spectrum, and in the quantum theory the intensity corresponding to any given angle of deflection of the rays by the grating must be expressed in terms of the probability of the light quanta undergoing such a deflection. This suggests the principle of correspondence for the investigation. The various mathematical sections of the paper deal with the Duane-Compton rules of quantisation, the infinite linear grating, the linear point lattice, and the space lattice. The considerations are restricted to the case of the Fraunhofer diffraction, and neglect the small change of the wave-length due to the Compton effect. They deal only with the linear momentum without reference to the possible changes of angular momentum and other quantic conditions of the system. This restriction seems natural, as only the linear momentum has a direct connection with the direction of motion of the light quantum. It appears that the photoelectric phenomena and the Compton effect can be explained only by the action of light quanta, while that of Fraunhofer diffraction can be treated as well on the basis of the wave theory of light as by a combination of the concept of light quanta with Bohr's principle of correspondence. The phenomena of coherence resist all attempts of the quantum theory. The treatment adopted means rather a readjustment than a complete abandoning of the wave theory.

H. H. Ho.

1813. *Fundamental Principles underlying the Technical Application of X-rays, with Especial Reference to Iron.* **K. A. Sterzel.** (Zeits. techn. Physik, 5. 1. pp. 22–29; 5. 2. 52–59; 5. 3. 88–94, and 5. 4. pp. 125–132, 1924.)—A series of four papers dealing with the fundamental principles of X-ray technique, with particular reference to the X-ray study of iron and steel of different kinds. The first paper deals mainly with the question of absorption coefficients of X-rays in materials, both simple and compound. The materials dealt with are those chiefly occurring in iron and steel manufacture, and include not only the irons and steels themselves, but also furnace materials (*e.g.* CaO, Cu phosphate, magnesia, graphite, gases, slag, etc.). A table of densities and absorption coefficients of many such materials is given, and X-ray photographs of defective iron castings (containing some of the above as impurities) are reproduced. In the second paper the question is considered of the loss of intensity of X-rays, both homogeneous and heterogeneous, in passing through different materials, especially in samples of iron containing air ("blowholes"). Whenever possible, simple practical working formulæ (with graphical representations) are deduced. The third paper deals with the scattering of X-rays in different materials, whilst paper four, in conclusion, deals with the blackening of photographic films by X-rays—in which case also simple working formulæ and graphical illustrations are given. A. B. W.

1814. *Studies in X-Ray Production.* **J. A. Crowther.** (Brit. J. of Radiology, 20. pp. 61–72; Disc., 96–99, April, 1924.)—The author describes tests made to determine the relative action of coils, transformers, tubes and breaks, by means of simultaneous records of potential and current, with corresponding records of quantity and quality of X-radiation. In his conclusions the author finds that the intensity is proportional to instantaneous values of the current and the square of voltage; the Coolidge tube acts as a thermionic valve, and is a constant maximum current device which, operated by a coil, owing to decrease of tube resistance, gives a variation of output due to change of secondary potential form. For gas tubes there exists a relation $i_m \propto V^2 - V_0^2$, where V_0 is breakdown voltage. The secondary peak voltage is proportional to value of primary current at the break. *Via* a gas tube (peak voltage)^2 is proportional to current at break. The discharge *via* a gas tube with a transformer is shown to be oscillatory in nature and having a frequency of 2000 per second, whilst the breakdown voltage increases during each discharge, returning to normal between each discharge. Tests were also made on the actions of various types of break. [See Abstract 1485 (1924).] B. J. L.

1815. *On the Quantity of the X-Rays excited in Hot Cathode and in Gas Tubes by Various Types of Generators of High-Tension Current.* **H. Moore.** (Brit. J. of Radiology, 20. pp. 73–96; Disc., 96–99, April, 1924.)—A lengthy paper giving results of comparative tests on Coolidge and gas tubes when operated at constant potential by transformers and by induction coils. Tests were made both by absorption *viâ* aluminium and by spectroscopic means. The source of constant potential was a direct-current machine giving 2·5 amps. at 100,000 volts and also a special three-phase rectifier apparatus. Results of the tests show that the efficiency of either type of tube is the same, and a maximum when operated at constant potential and then in descending order of efficiencies are: Gas tube at large alternate gap with transformer or coil; gas tube with small alternate gap with either transformer or coil; Coolidge tube with transformer; Coolidge tube with coil.

The alternative gap method of determining quality of radiation is shown, by spectra measurements, to be very inaccurate, and such measurements also show that a Coolidge tube is less efficient than a gas tube with either transformer or coil excitation. Dauvillier's observation, that the discharge *viâ* a gas tube at constant potential is intermittent, was found to be erroneous, and the intermittent discharge obtained by

Dauvillier is explained in terms of the small reserve of power present with the influence machine used by this observer, as compared to the large reserve of the 250-kw. machine used in the present experiments.

The advantage of the gas tube over the Coolidge tube in producing a harder general radiation is explained in terms of the discharge *viâ* a gas tube needing the application of a definite voltage before any current is passed, so giving a limit of radiation towards the longer wave-lengths, whereas, with the Coolidge tube, current passes whatever the applied voltage and more useless soft radiation is produced. As the voltage falls on reaching the critical voltage at which radiation ceases, the current stops, and no further radiation is given by the gas tube as opposed to the converse in the Coolidge tube. This effect would not presumably occur at constant voltage excitation, and both tubes would become equally efficient.

The operation of tubes above the critical voltage of the K-radiation for the particular material of the anti-cathode, in order to give a more homogeneous radiation, is then considered. The advantages of constant current operation are: homogeneity, greatest efficiency, quantity can be more accurately measured in terms of milliampere-seconds, quality is more accurately determined by voltage measurements, more accurate dosage measurements and possibility of their exact repetition. B. J. L.

1816. *Spark Lines in the X-Ray Spectrum.* **G. Wentzel.** (Ann. d. Physik, 73. 7–8. pp. 647–650, March, 1924.)—A supplement to a previous paper [see Abstract 1313 (1922)], in which the hard lines accompanying the series lines, without belonging to the series, are explained as "spark lines," *i.e.* as emissions from doubly or multiply ionised atoms. The theory explains the relations between the distances of the spark lines of the first and second order in the case of the Kα satellites of the light elements, according to the theory $(\alpha_3 - \alpha_1) < (\alpha_5 - \alpha_3) < (\alpha_6 - \alpha_4)$. The following table gives the frequency differences as measured by Hjalmar in Rydberg units :—

	12 Mg.	13 Al.	14 Si.	15 P.
$\alpha_3 - \alpha_1$	0·64	0·73	0·84	0·96
$\alpha_5 - \alpha_3$	0·66	0·79	0·90	—
$\alpha_6 - \alpha_4$	0·72	0·86	0·94	—

It will be seen that the $\alpha_6 - \alpha_4$ values for Mg, Al and Si are practically equal to the $\alpha_3 - \alpha_1$ values for Al, Si and P respectively, or $\alpha_6 - \alpha_4$ is equal to $\alpha_3 - \alpha_1$ for the next higher element, $(\alpha_3 - \alpha_1)_i = (\alpha_6 - \alpha_4)_{i-1}$. It is shown that this follows from the theory if the influence of a K electron on an L ionisation process consists simply in a screening of the nuclear charge to the extent of one unit. The above so far only applies to results with the K lines, since the L and M spark lines observed so far are only of the first order. The original idea of the author, that the excitations of the multiply ionised states are produced step by step by the removal of successive electrons, seems to be incorrect, since the duration of the ionised state is not long enough to allow of this. Rosseland's view, that two or three electrons are removed in a single excitation process, seems more probable. This agrees with the experiments of Coster and of Siegbahn. **H. N. A.**

1817. *Absorption Measurements of the X-Rays reflected from a Calcite Crystal.* **Y. H. Woo.** (Nat. Acad. Sci., Proc. 10. pp. 145–148, April, 1924.)—This paper describes: (1) the determination by an accurate absorption measurement as to whether there is a change of wave-length on reflection of X-rays from a crystal. According to Compton's quantum theory of the scattering of X-rays, there is a change of wave-length due to scattering of 0·0242 $(1 - \cos \theta)$ Å.U., where θ is the angle between the primary and secondary rays. If reflection of X-rays from crystals is a scattering phenomenon, it would seem that there might be a similar increase in wave-length on reflection. Experimental details and data are included for the use of a Bragg spectrometer and a Coolidge tube with a molybdenum target. It is found that, within the probable experimental error, the mass absorption coefficients are the same for the primary and reflected rays, so that the wave-length of X-rays undergoes no change on reflection from a crystal comparable with the above amount. (2) The determination as to whether there exists any appreciable difference in the absorption of an X-ray of the same wave-length before and after reflection from a crystal, since Compton has shown that if the absorption of X-rays is to be accounted for according to classical electrodynamics, there is a term for a transformation absorption which should appear in the expression for the total absorption in addition to the "tone absorption" and the scattering. Using the same apparatus as for (1), the existence of absorption due to transformation could not be detected.

H. H. Ho.

1818. *Secondary X-Rays.* **J. A. Gray.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 165–166, 1923.)—As a result of experiments, to be published later, the author has arrived at the provisional conclusion that the observed increase in softening of secondary X-rays with the atomic weight of the radiator is due to the presence in the secondary rays of X-rays formed by photo-electrons. With respect to the scattered X-rays which suffer a softening or decrease in frequency, it is believed that for a given angle of scattering and given type of X-rays the change in frequency is practically independent of the nature of the radiator. A. B. W.

1819. *Secondary and Tertiary X-Rays from Germanium, etc.* **G. L. Clark** and **W. Duane.** (Nat. Acad. Sci., Proc. 10. pp. 92–96, March, 1924.)—In three previous papers the authors have described experiments in which an X-ray beam, emergent from a secondary radiator at right-angles to the primary beam from a tungsten target, was analysed by means of a calcite crystal spectrometer. Results were given for fourteen different chemical elements from carbon (6) to neodymium (60). Three kinds of X-radiation were identified in the secondary beam: (1) scattered X-rays of same wave-length as the K series line of the primary beam; (2) fluorescent secondary rays, characteristic of the element in the radiator; and (3) tertiary rays produced by impact of secondary photoelectrons in the radiator. In the present note additional experimental evidence is given bearing on these phenomena. Ionisation spectrometer curves are given indicating the secondary and tertiary radiation from silver and germanium. Previous results on scattering by a graphite plate have been confirmed by using a paraffin block. The results obtained do *not* confirm A. H. Compton's theory of change of wave-length on scattering. [See Abstracts 869 and 1491 (1924).] A. B. W.

1820. *Secondary and Tertiary X-Rays from Chemical Elements of Small Atomic Number.* **G. L. Clark, W. Duane** and **W. W. Stifler.** (Nat. Acad. Sci., Proc. 10. pp. 148–152, April, 1924.)—Using primary rays from a water-cooled molybdenum target and secondary radiators of lithium, graphite, ice, rocksalt, aluminium and sulphur, tertiary radiation, in accordance with theory, was observed in all cases [see Abstracts 869 and 1491 (1924) and preceding Abstract]. The observations indicate that the rays with wave-lengths shifted towards larger values should be ascribed to tertiary radiation produced by the impact of photoelectrons; that is, Compton's theory of wave-length shift at scattering is considered incorrect. A. B. W.

1821. *Intensity of X-Rays scattered from Rocksalt.* **G. E. M. Jauncey** and **H. L. May.** (Phys. Rev. 23. pp. 128–136, Feb., 1924.)—Rays from a molybdenum target (47·5 kv.) filtered through a zirconium phosphate screen were directed on to a thin slab of rocksalt at an angle θ with the normal to the face, and the scattered intensity after transmission was measured with a long ionisation chamber at various angles ϕ with incident radiation. Assuming the scattering independent of θ and eliminating μ by using Crowther's expression for the scattering coefficient when $\theta = \frac{1}{2}\phi$, scattering in excess of theoretical (Thomson) was observed for ϕ between 9° and 90°, the two maxima at 15° and 30°, about twice theoretical, corresponding respectively to maxima in the incident radiation at about 0·4 Å. and 0·7 Å. respectively. Similar excess scattering at 20° to 30° had previously been reported for amorphous carbon and liquids, but in these cases the excess scattering might have been due to a powdered crystal effect. The scattering drops suddenly to zero at 5°, about the same angle as that for which regular reflection becomes zero. Above 90° the scattering also departs somewhat from the Thomson curve, showing a minimum for about 100°; it corresponds in shape better with the curve given by the quantum theories of A. H. Compton and Jauncey, the experimental value being, however, greater in the ratio 9/8. The mass-scattering coefficient for the primary rays used (0·4 to 0·7 Å.) comes out 0·23 ± 0·02 as against Thomson's value of 0·193. AUTHOR.

1822. *The Scattering of X-Rays by Hydrogen.* **G. A. Schott.** (Phys. Rev. 23. pp. 119–127, Feb., 1924.)—Measurements of the absorption and scattering of X-rays by hydrocarbon compounds made recently by Aurén, by Hewlett, and by Olsen, Dershem and Storch, are considered critically in so far as they serve for the calculation of the mass-scattering coefficient of hydrogen for different wave-lengths and its comparison with the results computed on the basis of (1) the Simple Pulse theory, (2) the Electron Ring theory, (3) the Ring-electron theory, and (4) the Quantum theory of scattering recently proposed by A. H. Compton. It is found that none of these theories, even when it is interpreted in the widest sense, agrees with the experimental results over the whole range of wave-lengths. This failure may very well be due to the inaccuracy in the experimental results, since the method of calculating the mass-scattering coefficient from measurements made upon compounds necessarily magnifies the experimental errors very considerably owing to the smallness of the scattering of hydrogen as compared with that of the remaining constituents. The importance of obtaining reliable data is pointed out, and it is suggested that sufficiently accurate results can be secured only by using the element in the free state, either in the liquid form or as gas under high pressure. AUTHOR.

1823. *Scattered Röntgen Rays. Part I. The Azimuthal Distribution of Scattered Röntgen Rays.* **W. Friedrich and M. Bender.** (Ann. d. Physik, 73. 7–8. pp. 505–553, March, 1924.)—In this paper the azimuthal intensity distribution of scattered radiation proceeding from a number of simple bodies is investigated. The results for all experimental material show that, mainly with small azimuths, considerable deviations from the Thomson distribution are present, which can be explained as due to interatomic interference in the Debye sense. The results are compared with the newer views on the build of the atom. No agreement is found between measurement and calculated results for the elements Na and K with eleven and nineteen electrons; for Li, with three electrons, the agreement is approximate; also for water and alcohol over a great range an approximate agreement is found. It is not to be wondered at that the agreement for lower atomic numbers is better than for higher, since the constellation possibility of electrons with elements of lower atomic number is not so great as with higher. It is intended to carry out experiments on the azimuthal scattering distribution for other wave-lengths, and also to work with smaller bundles of rays and with smaller azimuths.

There is a note appended by the referee to the effect that the assumption is made in this paper that the wave-length of the Röntgen rays is not altered by the scattering process, and that, since recent researches of Compton [see Abstract 2194 (1923)] and theoretical considerations of Debye [see Abstract 1878 (1923)] have shown that an alteration of the wave-length with scattering takes place, the results here obtained need correction. A. E. G.

1824. *Measurement of Polarisation of Secondary X-Rays.* **A. H. Compton and C. F. Hagenow.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 487–491, April, 1924.)—It was observed by Barkla [see Abstract 712 (1906)] that the intensity of X-rays scattered from the second radiator perpendicular to the theoretical plane of polarisation was about one-third as great as the intensity of radiation in the plane. Since then evidence has accumulated that secondary X-rays even from light elements are not of the same wave-length as the primary rays. If this difference of wavelength is due to fluorescent radiation, it should result in an incomplete polarisation of the scattered rays. The object of the present experiments was to test this point by measurement of the degree of polarisation of the scattered rays. Heterogeneous X-rays of an average wave-length of about 0·25 Å. were scattered by paper, aluminium, and sulphur. A geometric correction was made for the lack of complete polarisation due to the solid angles subtended by the radiators, and the results were extrapolated to zero thickness of the radiators. The experiments indicate that within a probable error of 1 or 2 %, the radiation is completely polarised. This precludes the possibility of there being any considerable amount of fluorescent radiation emitted by the radiator. A. B. W.

1825. *Direction of Ejection of Photo-Electrons by Polarised X-Rays.* **F. W. Bubb.** (Phys. Rev. 23. pp. 137–143, Feb., 1924.)—Stereoscopic photographs have been obtained, by Wilson's cloud method, which show the ionised tracks of photo-electrons ejected by plane polarised X-rays. The polarised X-rays scattered by a paraffin block at 90° to an unpolarised primary beam of hard X-rays, were directed horizontally through the expansion chamber of a Wilson cloud apparatus in which they produced photo-electrons. Exploded tungsten wires furnished the instantaneous illumination of the droplets. The photographs, taken with the plate at 90° to the polarised beam, show two types of asymmetry in the direction of ejection of the photo-electrons. (*a*) *Lateral asymmetry.*—There is a strong concentration of photo-electrons ejected nearly in the direction of the electric vector of the plane polarised X-radiation. (*b*) *Longitudinal asymmetry.*—Stereoscopic examination shows one-sixth of the photo-electrons ejected with a component opposite to the beam, one-third ejected approximately at right angles to the beam, and one-half ejected with a component along the beam. The results are stated to be in accordance with the classical theory. Attempts are also made to explain results on a quantum basis. A. B. W.

RADIO-ACTIVITY.

1826. *Purification of Radium Emanation.* **V. F. Hess.** (Phil. Mag. 47. pp. 713–721, April, 1924.)—In the introduction the author refers briefly to the methods employed by Ramsay and Soddy [Abstract 2558 (1904)], Rutherford [Abstract 1798 (1908)], Debierne [Abstract 1056 (1909)], Lind, Duane, and others in separating pure Ra emanation from the solution of radium salt. A description is then given of an apparatus, used by the author, which gives quick and efficient purification of RaEm from foreign gases, such as hydrogen, oxygen, CO_2, etc. The process is based on a combination of known chemical reactions; the equivalent amounts of hydrogen and oxygen are combined by the electric spark; water-vapour and CO_2 are absorbed. The final purification is done by heating a small piece of copper-oxide wire in the capillary tube, thus reducing the excess of hydrogen. The apparatus is small enough to be kept in a safe together with the radium solution. Only one automatic vacuum pump is used. A special device makes it possible to increase the vacuum given by the pump about 100 times. The apparatus is detachable and can be cleaned inside without cutting glass connections. The process of purification of emanation takes about 15 minutes and gives a final concentration of approximately 1 millicurie per cubic millimetre. For higher concentrations it is necessary to use liquid air. The apparatus can be used with solutions containing from 50 mgms. of radium upwards. A. B. W.

1827. *The Emanation Method for Radium.* **F. E. E Germann.** (Science, 59. pp. 340–341, April 11, 1924.)—In using the emanation method, as developed by Schlundt and Moore, [see Abstract 1596 (1905)], and by Lind, in radium analyses, or calibrating a β-ray electroscope, it is best to draw out and seal the neck of the flask, and not to use a rubber stopper or rubber tubing; the tip must be broken off after the flask has been connected by means of tubing to the emanation gas burette, but the small piece of glass broken off frequently lodges in the lower stop cock of the burette, and spoils the experiment. Three forms of trap are described which prevent this; in the simplest and most effective of these the flask is connected by rubber tubing to a short length of tube which slopes upward to join the horizontal tube leading to the burette, at an angle somewhat less than 90°; the inclined tube is prolonged a few millimetres past the joint, forming a tiny hemispherical trap, into which the glass tip may be projected, and fall back again, without lodging in the horizontal tube.

H. N. A.

1828. *"Radium" Recording Devices.* **J. H. Powell.** (Journ. Sci. Instruments, 1. pp. 205–209, April, 1924.)—In the radiation type of "radium" recording device, a small brass capsule of cylindrical form takes the place of the recording pen, one end is closed and a small speck of radio-active material is attached to the inner surface in the axis of the cylinder; at the other end is a small circular hole, 0·65 mm. diameter, which allows a beam of radiations to fall upon photographic paper on a revolving drum; as there is no friction between the "pen" and the paper the method is very suitable for cases where there is very little power available to operate the mechanism. The recording drum need not be kept in the dark, since the photographic paper can be covered by a thin layer of opaque material, which allows the β- and γ-rays to penetrate, and produce the photographic effect. Black paper was used; but if the light is not strong it is better to use very thin celluloid sheets stained with a "safe" photographic red stain, which cuts off less of the α-radiation; the photographic paper itself may be stained red, which makes it insensitive to light while it remains sensitive to the radium rays; it is possible to wash out this stain during development. For use in the open air, however, the black paper answers best. In the luminous paint type of recorder, light from a luminous radium compound passed through a slit in the "pen," perpendicular to the axis of the revolving drum, and through a fixed vertical slit parallel to the axis of the drum, the two slits are close to the surface of the photographic paper, and as the drum revolves a recording line is photographed upon it. This method can be used in apparatus completely immersed in sea water. The shadow type of recorder is used to record the movement of a column of liquid in a cylindrical tube, as in a barometer. The tube is surrounded by a cylindrical metal sheath, with a narrow longitudinal slit, the interior of the sheath being coated with the luminous compound; the recording drum is placed as near as possible to the slit, with its axis parallel to it; the shadow of the mercury is printed on the photographic paper.

H. N. A.

1829. *Extraction and Recovery of Radium from Typical American Carnotite Ores.* **H. H. Barker** and **H. Schlundt.** (Univ. of Missouri, Bull. 24. 26. pp. 3–87, Sept., 1923.)—The methods used for the extraction of radium from uranium ores are grouped under the three headings: (1) Direct solution by means of acids, with or without preliminary conversion of the radium and barium into carbonates; (2) concentration of the radium by reduction of the gangue material; (3) miscellaneous processes. These are discussed in detail, and their advantages, disadvantages, and conditions of application indicated. For control work in plant operations and for the measurement of radium in general three standard methods are used: the emanation, gamma-ray, and alpha-ray methods. The application of these methods to the case of carnotite ores, and the chemical treatment of the latter involved, are described in detail.

A new method for charging electroscopes, due to le Roy and Schlundt, consists in transforming an ordinary lighting circuit voltage, say 110 volts, to 3000 volts, rectifying this by means of a " kenotron " rectifying tube, and using a special high-resistant potentiometer to secure any potential required to charge the leaf system of the electroscope to the desired degree.
T. H. P.

1830. *The Amount of Ionium-Thorium in Uranium Pitchblende from St. Joachimsthal.* **S. Meyer** and **C. Ulrich.** (Akad. Wiss. Wien, Ber. 132. 2A. No. 7–8. pp. 279–284, 1924.)—A number of investigators have dealt with the ionium in ore from St. Joachimsthal, but all have used the same material, which was prepared by working up 30,000 kilograms of pitchblende produced before 1905, as described by Haitinger and Ulrich. The combining weight of this thorium-ionium is 231·51, while that of pure thorium is 232·12, so that the mixture of isotopes contains about 30 % Io and 70 % Th; the mean duration of life of ionium, using the latest data, is $\tau = 9 \times 10^4$ years $= 2\cdot 8 \times 10^{12}$ sec., and the disintegration constant $\lambda = 2\cdot 4 \times 10^{-13}$ sec.$^{-1}$; from this the range is calculated, using Geiger's formula, to be $R_0 = 3\cdot 029$ cm. in air at 0° C. and 760 mm. pressure; Geiger found $R_0 = 3\cdot 028$ cm. The above mixture is designated Io-Th (I). A new mixture has been separated from ores obtained in 1912 and 1913, and is designated Io-Th (II); another fraction, produced from the same ore sample, separated at a different stage of the chemical process, is designated Io-Th (III); Io-Th (II) is more active than Io-Th (I), and it was shown that this was not due to any extent to the presence of radio-actinium. The modified Geiger-Nuttall method was used to determine the range, which was found to be $R_0 = 2\cdot 96$, as compared with the previous value 3·028 cm.; the Io–Th O_2 was in a thin, but of course not an infinitely thin layer, which may account for the small reduction of range; it is nearly certain that the α-radiation is due to ionium alone. A comparison of the radiation from IoTh (I) and IoTh (II) shows that the latter contains about 50 % of ionium, and the combining weight of the mixture should be about 231·1; Io-Th (III) contained a considerable amount of RdAc; but it appears probable from the measurements that when this has disintegrated it becomes identical with Io-Th (II). The fact that the percentage of thorium varies from 70 to 50 is discussed with relation to the theory of Kirsch, that thorium is produced from a hypothetical isotype of uranium, thorium-uranium, with a half life period of about 60 million years.
H. N. A.

1831. *Renewed Measurements of the Radioactivity of the Gastein Thermal Springs.* **H. Mache.** (Akad. Wiss. Wien, Ber. 132. 2*a*. No. 5–6. pp. 207–214, 1924.)—Measurements were made in the summer of 1904, and it is fortunate, in view of the fact that the methods of measurements were at that time not fully developed, that a method was employed which makes a comparison with new measurements possible. Details are given of the amounts of emanation and of radium in the different springs, with notes as to the places from which the water was taken and of any changes which have been made which could affect the springs since 1904; where no such changes have been made the amount of emanation has hardly altered at all, though there are small annual variations corresponding to the flow of each spring. The early observations of the amount of radium are not numerous; the new observations do not, in general, indicate much change. It seems possible that springs which form a deposit in their channels, which is rich in radium, may wash out some of this deposit when their flow increases, and so show a higher radium content. Roughly speaking, the emanation content is larger in the cool springs and the radium content in the hot springs. H. N. A.

1832. *The Large-Angle Scattering of α-Particles by Light Nuclei.* **E. S. Bieler.** (Roy. Soc., Proc. 105. pp. 434–450, April 1, 1924.)—The arrangement of the radio-active source, scattering foil and fluorescent screen was the same as in Chadwick's experiments on scattering and in those of Chadwick and Bieler on the collision of α-particles with H nuclei; foils of aluminium and of magnesium were employed and their thickness determined by weighing either with a chemical balance, or with a special micro-balance with which foils of the order of a few tenths of a milligram could be weighed to 1 %. Two forms of apparatus were employed, the relations between source, foil and screen being the same in both, but the second having a special arrangement to prevent the radioactive contamination of the inside of the box, which with large angles of scattering, when the amount of scattering is small, is sufficient to completely spoil a count; the source is contained in a separate chamber, which is separated from the larger chamber containing the foil by a film of collodion, of stopping power less than 1 mm. of air. Both chambers are evacuated. Curves were obtained showing the ratio between the scattering for the light metals and that for gold in relation to the angle of scattering; they indicate that at very small angles the scattering is very approximately that which would be expected on the inverse square law; when they are compared with the previous theoretical results of the author the curves indicate the existence of an inverse fourth power attractive force, in addition to the electrostatic inverse square law repulsive force. The two forces are equal and the resultant is zero, in the case of aluminium, at a distance $3\cdot44 \times 10^{-13}$ cm. from the centre of the nucleus; this may be regarded as the effective radius of the nucleus; some of the nuclear electrons may be outside this radius, though in spite of this the estimate seems small for a nucleus with 14 electrons and 27 protons. The calculated apsidal distance of an α-particle of 7 cm. range, deflected through 180°, is $4\cdot6 \times 10^{-13}$ cm. which seems to show that the estimate for the radius of the nucleus is not much too low. The additional force postulated would have no noticeable effect on spectral lines, since it will be very small in the outer electron layers. H. N. A.

1833. *The Bombardment of Elements by α-Particles.* **E. Rutherford** and **J. Chadwick.** (Nature, 113. p. 457, March 29, 1924.)—The authors mention difficulties which arise when the ranges of the H-particles produced by bombardment are less than 30 cm. in air, and describe a method for observing the disintegration of an element, when the ejected particles have a range of only 7 cm. in air. A powerful beam of α-rays falls on the material, and the liberated particles are observed on a zinc sulphide screen, at an average angle of 90° to the direction of the α-particles; the presence of H in the bombarded material produces no effect on the screen; the results are independent of H nuclei from the source and of the long-range particles found by Bates and Rogers; the latter are just detectable with gold, but are inappreciable with lighter materials; gases can be examined as well as solids. Neon, magnesium, silicon, sulphur, chlorine, argon, and potassium give particles of range above 7 cm.; the numbers are small as compared with those from aluminium under the same conditions, from 1/3 to 1/20; neon appears to have the shortest range particles, about 16 cm.; the ranges of the others are between 18 cm. and 30 cm.; beryllium seemed to give a small effect, but this may be due to fluorine as an impurity; H, He, Li, C, and O give no detectable effect; sulphur, which is probably a "pure" element of mass $4n$ gives an effect of nearly 1/3 that of aluminium; this shows that the nucleus is not built up solely of He nuclei, which is also suggested by the atomic weight 32·07. No definite results have been obtained with the elements from calcium to iron, owing to the difficulty of getting rid of active impurities; pure electrolytic iron gave no particles. No effects were observed from Ni, Cu, Zn, Se, Kr, Mo, P, Ag, Sn, Xe, Au, and V. In the case of the lighter elements it should be possible to carry the examination down to ranges of about 3 cm.

H. N. A.

1834. *The Disintegration of Atomic Nuclei.* **H. Pettersson.** (Phys. Soc., Proc. 36. pp. 194–202; Disc., 202–204, April, 1924.)—The author claims that the disintegrability of atomic nuclei is universal and not a property of a limited number of elements. This casts some doubt on the satellite theory of nuclear disintegration and another theory is advanced which is called an explosion theory. According to this, the stability of the equilibrium between positive and negative charges in a nucleus is disturbed by the approach of an α-particle, and if the encounter is close, actual disruption of the atom will occur. Several lines of experimental research are suggested further to discriminate between the two mechanisms. *Discussion.*—**J. H. Vincent** pointed out that the universal disintegrability of atoms would explain the simultaneous existence of several radioactive families. **C. W. Hume** suggested that if the principle were admitted to apply to the heavy nuclei, the life of radio-active bodies should be shorter when they are in concentrated than in dilute form.

A. Wh.

HEAT.

1835. *The Effect of Temperature on the Properties of Metals.* **A. Mallock.** (Roy. Soc., Proc. 105. pp. 129–134, Feb. 1, 1924.)—Experiments carried out on the coefficients of rigidity, thermal expansion, viscosity, and specific heats of iron between 14° C. and 1000° C. The expansion was measured: (*a*) By an automatic record of the variations of the length of a wire in a heating coil and (*b*) by an automatic record of the variation in length of a wire 10 miles long and 0·02 inch diameter, heated by passing a current through it and allowed to cool by radiation, the wire being enclosed in a wide tube filled with nitrogen. Iron, and steels of various carbon contents, were studied and the results obtained are illustrated in six figures.

J. L. H.

1836. *Calorimetry of Saturated Fluids.* **N. S. Osborne.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 519–540, April, 1924.)—This paper analyses the theory of certain calorimetric processes for the determination of the more important thermodynamic properties of saturated fluids; and deals with the interpretation of the theory as bearing upon its experimental application. It is shown that three particular types of calorimetric process make up an experimental series, and three quantities, each characteristic of one of the processes, are determined by the measurements as functions of the temperature or pressure. From these three characteristic functions alone most of the important properties of a saturated fluid are obtained directly, including the heat contents, entropies, specific heats, and specific volumes.

S. L. S.

1837. *A New Application of the Bar Method for the Measurement of Thermal Conductivity.* **M. D. O'Day.** (Phys. Rev. 23. pp. 245–254, Feb., 1924.)—If both ends of a bar be kept at the same constant temperature, and the bar carries an electric current I, the equation of heat flow when the steady state is attained is

$$A\frac{d}{dx}\left(K\frac{d\theta}{dx}\right) - Is\frac{d\theta}{dx} + (JI^2R_0a - h)\theta = -JI^2R_0$$

A is the sectional area of the bar, R_0 the resistance per cm. at the end temperatures, *s* the coefficient of the Thomson effect, and *h* is the product of the emissivity and perimeter of the bar. Two modifications of this have been used by the author for determining *k*.

Method I.—As previously suggested by Callendar, alternating current is employed when the second term in the equation vanishes and the magnitude of the current is adjusted to make the third term zero. For this, *h* must be known. This can be found by passing a small current along the bar when the temperature gradient at the middle is zero and $h\theta_m = JI^2R_m$. With the critical alternating current it is shown that $k_0 = JI^2R_0L/Ap_0$, where p_0 is the temperature gradient at the ends of the bar and 2L is the length. The mean conductivity k_m is $JI^2R_0L^2/2A\theta_m$, from which the temperature coefficient of thermal conductivity β can be calculated, $k_m = k_0\{1 - \frac{1}{2}\beta\theta_m\}$.

Method II.—The magnitude of the alternating current is adjusted until the temperature distribution along the bar is parabolic. It is not necessary to know the value of h by this method. When the critical current for this temperature distribution passes, $\theta_m = \frac{1}{2}Lp_0$. The condition can be experimentally realised from observations of the variation of $\theta_m - \frac{1}{2}Lp_0$ with the current. The value of k_0 is JI^2R_0L/Ap_0. The method fails when $\alpha - 3\beta$ is very small or negative.

Thomson Effect.—If direct current of the same value as that for the parabolic temperature distribution be used, and the change of temperature $d\theta$ at a point $0\cdot42L$ from the end be observed when this current is reversed, then $s = A^2k_0d\theta/0\cdot128JI^3L^3R_0$. The apparatus employed consisted of a bar about 30 cm. long bent into an inverted **U**-shape. The ends were screwed into copper blocks, 2 in. diameter, 1 ft. long, separated by mica. The blocks were in the same oil-bath, which was kept well stirred. The bar was covered with wool yarn and surrounded by an inverted Dewar flask. Five thermocouples attached to the bar gave the gradients at the ends and the mid. pt. temperature. For lead, Method I was employed, giving $k_0 = 0\cdot0877$, $\beta = 0\cdot000138$. For tin, Method II was used, giving $k_0 = 0\cdot1575$, $\beta = 0\cdot00067$. The coefficient of the Thomson effect for tin at 38° was $9\cdot7 \times 10^{-7}$ cal. per coulomb per sec. L. L.

1838. *Platinum Resistance Thermometer Temperature Scale Between 0° and − 193°.* **F. Henning** and **W. Heuse.** (Zeits. f. Physik, 23. 1–2. pp. 95–104, 1924.)—Henning has previously calibrated platinum-resistance thermometers over the range 0° to − 193°, using the constant-volume hydrogen thermometer [Abstract 1169 (1913)]. A table was constructed giving the resistances of Pt thermometer No. 32 of the Reichsanstalt over this range, and readings by other Pt thermometers could be reduced to No. 32 by the equation $r - r_{32} = a(1 - r_{32}) + b(1 - r_{32})^2$, where r = (resistance of the thermometer at t°)/(resistance at 0°). Measurements of the resistance at the boiling-points of O and CO_2 served to determine the constants a and b.

New data have now been obtained for seven Pt thermometers over this same range. A constant-volume He thermometer was used for the calibration. The bulb, of glass 59^{III}, had a capacity of 300 c.c. The initial pressure at 0° C. was 1000 mm. Hg. The resistance ratio over this range can be represented by

$$r = R/R_0 = 1 + a(t/100) + b(t/100)^2 + c(t/100)^4.$$

For No. 32

$$a = +\ 0\cdot396952, \quad b = -\ 0\cdot0064408, \quad c = -\ 0\cdot000508065.$$

To determine a, b, c, suitable fixed points are the melting-point of Hg (− 38°·87), sublimation point of CO_2 (− 78°·51), and the boiling-point of O (− 183°·00). The Callendar formula holds with sufficient accuracy down to − 40° C. For the seven thermometers used the Callendar constant α had values between $0\cdot0038624$ and $0\cdot0039150$, and the constant δ values between $1\cdot510$ and $1\cdot482$. The authors consider that if the constants, α and δ, lie between these limits c can be taken as $-\ 0\cdot000508065$. Two fixed points then suffice to determine a and b.

If, in addition, the values of α and δ be known, R/R_0 at the melting-point of mercury can be determined from the Callendar equation, and only one fixed-point determination of resistance is necessary. A new determination of the melting-point of mercury was made and found to be $-38°\cdot87 \pm 0\cdot01$.
L. L.

1839. *The "Pyro" Radiation Pyrometer.* (Engineering, 117. pp. 493–494, April 18, 1924.)—A description of a compact type of total radiation pyrometer. It consists of a telescope with a sensitive thermo-element at its focus. This couple is contained in an evacuated glass bulb. It is connected to a moving coil indicator constituting an integral part of the telescope. The operator sights the instrument on the furnace or hot object, and takes care to ensure that the image of the furnace-opening completely covers the thermocouple disc. He presses the button, which releases the moving coil; the pointer then takes up the position corresponding to the temperature of the furnace.

Equilibrium is attained in about two seconds; the observer then releases the button, and this clamps the moving coil in the position it has taken up. The instrument is read after lowering it from the eye. No focussing is required if the instrument is used within the correct distance limit. E. G.

1840. *Radiation Pyrometry.* **H. Schmidt.** (Zeits. f. Physik, 23. 3–4. pp. 225–228, 1924.)—O. Lummer and E. Pringsheim, in agreement with the Wien displacement law, $\lambda_m T =$ constant, find $\lambda_m T = 2940$ for a black body. Their measurements on polished platinum give, by analogy, $\lambda_m T = 2630$. At the same time they suggest that the temperature of any radiator can be found by determining λ_m and employing the last two results to give an upper and a lower limit to the temperature T. The equation $\lambda_m T =$ constant (and analogous equations) do not, however, impose the condition that A is independent of λ and T, so that these equations are strictly applicable only to black or grey radiators [see Abstract 1068 (1919).] The author concludes that the observation of the position of the maxima of the energy radiated from a heat radiator, together with the Wien displacement law and the analogous law for bright platinum, are not sufficient to give for the temperature of the radiator an upper and a lower limit. T. B.

1841. *The Nature of Thermal Radiation.* **M. Planck.** (Ann. d. Physik, 73. 3–4. pp. 272–288, Jan., 1924.)—Wien provided a means for the closer study of the characteristic properties of thermal radiation by introducing the idea of radiating entropy, which Einstein further elaborated by the use of Boltzmann's relationship between entropy and probability, and v. Laue [see Abstract 1289 (1915)] still further generalised by a purely statistical method. From the energy variation law Einstein has deduced that the classical undulation theory of light in this case is incompatible with the demands of the quantum theory. The present author opines the problem to be not completely solved as yet, and he refers to a discussion between Einstein and v. Laue [see Abstracts 95, 96 and 218 (1916)], which revealed deviating points of view. In particular Planck states that Einstein's assumption, that on the classical wave theory the stationary monochromatic thermal radiation may be held to arise by the superposition of a very large number of independent radiations, requires further proof. In the present paper the special case for a single degree of freedom is considered, in order to derive, in the first place, the statistical law of formation which the Fourier coefficients [*loc. cit.*] must fulfil if the dimensions of the average square of the energy variations should satisfy the demands of the quantum theory, quite apart from the question of the physical origin of the radiation, and also to establish the actual Fourier series belonging to this formation law. The paper is entirely mathematical. H. H. Ho.

1842. *The Liquefaction of Hydrogen and Helium, Part III.* **J. C. McLennan and G. M. Shrum.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 21–33, 1923.)—Previous papers [see Abstracts 1151 (1922) and 2459 (1923)] have described the high-efficiency liquefiers in use at Toronto University. The present paper supplies some additional notes.

Dewar flasks suffer under the disadvantages of ease of breakage and smallness of capacity, while metal containers had proved unsatisfactory until the repair of a damaged one showed a great improvement. Successful insulation depends on correct polish, correct preparation and disposition of the material in the interspace, and proper vacuum between the shells. It was found to be essential that polishing, assembling, transference of the heat-treated charcoal, and the preliminary exhaustion should occur without delay. Diagrams and a detailed account of procedure are given.

Some additional features of the *hydrogen cycle* are given, including an apparatus for the preliminary purification of commercial hydrogen, it being first passed over heated palladiumised asbestos to remove the oxygen, then through a purifier containing charcoal at liquid-air temperature, and then to the final purifier previously described.

An apparatus for the *liquefaction of helium*, on the same principles, but on a reduced scale (about ⅓) is described, and has been used with success. The liquid is colourless, but its meniscus differs from that of hydrogen. Samples of the gas showed no trace of hydrogen, but the purity of the gas was evidenced by the free working of the expansion valve throughout. W. G. B.

1843. *Apparatus for Determining Melting and Freezing-Points of Pure Substances and of Eutectic Mixtures.* **E. W. Washburn.** (Indust. and Engin. Chem. 16. p. 275, March, 1924.)—The apparatus consists of a Dewar vessel made of Pyrex glass, and can be used for any temperature up to 500° C., the temperature being measured by a mercury thermometer or a thermocouple. The method is applicable to substances which melt either above or below the room-temperature. The results obtained with this apparatus show great constancy, and in the case quoted of Mannite the temperature remained constant to 0·01° C. during the time of crystallisation, 10–15 minutes. F. J. B.

1844. *Some New Standard Melting-Points at High Temperatures.* **H. S. Roberts.** (Phys. Rev. 23. pp. 386–395, March, 1924.)—After purification by crystallisation from solution, a gramme of the salt is placed in a platinum crucible 18 mm. by 10 mm. in diameter, the junction is placed in the axis and 3–4 mm. from the bottom, and the temperature is raised about 5° per minute. For most pure substances and certain eutectics the heating curve becomes quite flat at the melting-point, and hence the form of curve obtained is a sensitive test of purity. The couples used were carefully calibrated with standard metals, and gave the following results, accurate to ± 0·5°: potassium dichromate 397·5°; (30·5 NaCl + 69·5 Na_2SO_4), 627·0°; KCl 770·3°; NaCl 800·4°; Na_2SO_4 884·7°; K_2SO_4 inversion point 583 ± 1°; melting-point 1069·1°; also $Ca_2B_2O_5$ 1304 ± 5°. Detailed suggestions as to technique are given, also a convenient method of using pure metal strips or wires in calibrating couples. AUTHOR.

1845. *Determination of the Normal Boiling-Points of Oxygen, Nitrogen and Hydrogen.* **F. Henning** and **W. Heuse.** (Zeits. f. Physik, 23. 1–2. pp. 105–116, 1924.)—The boiling-point of O has been previously determined by Henning [Abstract 694 (1914)], using two Pt thermometers calibrated by means of a constant-volume H thermometer. More recently [Abstract 1998 (1921)] two constant-volume He thermometers were used to determine the normal boiling-point of H. Values of these fixed points have also been lately published by Kamerlingh Onnes and his collaborators at Leyden. They give the normal boiling-point of O, $-182\cdot95^{03}$, N $-195\cdot78^{03}$, H $-252\cdot75^{04}$. In these determinations the pressure-coefficients of H and He were obtained indirectly, and the values used do not agree with those recently obtained by the present authors [Abstract 589 (1922)]. For this reason the Leyden and Charlottenburg temperature scales may differ by as much as 0°·1 at the lowest temperatures. On similar grounds objections may be made to the determination of the boiling-point of O(− 182°·94) by Keyes, Townshend and Young. In the present paper the authors describe the determination of these fixed points, using two gas thermometers [Jena glass 59^{III}] of capacities 300 c.c. and 100 c.c. and with five different fillings of He. The critical pressure at 0° C. was about 1000 mm. Hg. For each separate filling the pressure coefficient was determined, the value 0·0036600 being in good agreement with previous values. The static method was employed for the O and N points, and the dynamic method for H. The final results reduced to the thermodynamic scale of temperature are—

Oxygen	− 183·00 ± ·02
Nitrogen	− 195·81 ± ·02
Hydrogen	− 252·78 ± ·02

Over the range − 183° to − 205° the variation of the boiling-point of O with pressure is given by the equation $\log p_{mm} = -379\cdot95/T - 0\cdot0096219T + 1\cdot75 \log T + 4\cdot53939$, where $T = 273\cdot20 + t$, and for N by $\log p_{mm} = -301\cdot91/T - 0\cdot0090272T + 1\cdot75 \log T + 4\cdot17643$. The resistances of two Pt thermometers used over a period of twelve years in this work were again measured at these fixed-point temperatures. The values have remained practically constant, the greatest observed alteration only corresponding to a change of temperature of 0·02°. L. L.

1846. *Estimation of Latent Heats of Vaporisation of Liquids at High Pressures.* **W. H. McAdams** and **J. C. Morrell.** (Indust. and Engin. Chem. 16. pp. 375–378, April, 1924.)—For the purpose of estimating the latent heat of vaporisation, Trouton's rule has been widely used: Mr/T_a = a constant, where M is the molecular weight, r the latent heat and T_a the boiling-point. The rule, however, is known to be approximate only, and refers to atmospheric pressure. When Mr/T is plotted against 1000 P/T where T is the absolute boiling-point at any pressure, P being the corresponding vapour pressure, the empirical relation so obtained is called the "Hildebrand function." In the present paper the range of the Hildebrand function has been greatly extended, especially in the region of higher pressures. In order to render extrapolation less liable to error the values of Mr/T are plotted (on ordinary rectangular scale) against $1000\ P/T$ on a logarithmic scale. The liquids thus dealt with are water, chloroform, benzene, carbon-bisulphide, carbon-tetra-chloride, ethyl ether, and acetone. An interpolation table is also given for the application of W. K. Lewis's method of estimating the approximate molecular weight of mixtures of hydrocarbons, with illustrations showing the use of the curves and tables. T. B.

1847. *Thermal Emission and Evaporation from Water.* **M. Allen.** (Nat. Acad. Sci., Proc. 10. pp. 88–92, March, 1924.)—The author has determined a quantity which he calls the "thermal emission from a water surface," consisting of radiation convection and conduction, comparable with the emissivity determined by Macfaralane (Roy. Soc. Proc. 20. p. 90, 1871) for copper spheres, later verified and extended by Bottomley [Abstract 1651 (1908)], who varied the pressure of the air in the enclosure, and at low pressures was able to verify Stefan's fourth power law. In dealing with the problem of thermal emission from water, the rate of evaporation has been found and studied as a function of the vapour pressures of water at the temperature of the hot water and of the surrounding envelope.
A. B. W.

1848. *The Changes of the Curves of State between Arbitrary Boundary Curves with Applications to Water, Carbon Dioxide, and Air.* **V. Fischer.** (Zeits. techn. Physik, 5. 1. pp. 17–21; 5. 2. 39–44; and 5. 3. pp. 83–88, 1924.)—This is a paper divided into three sections. In the first the author, after stating that the p, v and entropy-temperature diagrams of thermodynamics have not fulfilled a very useful purpose in technical thermodynamics, refers to the work of Mollier, who introduced the idea of heat-content at constant pressure as one of the coordinates and the $J-p$ diagram, which has found far-reaching application in technical work. Further investigations on specific heats at constant pressure and their dependence on temperature of pressure were necessary, and these were carried out by Knoblauch, Witkowski and Bridgman. This led to the introduction of the cp, T and cp, p diagrams. The author makes the cp, T diagram the basis of his system of equations. In the first section 33 equations are developed. In the second the mean specific heat is calculated and changes of state which take place in the region of saturation; a further 35 equations are developed. In the third section graphical methods are used to evaluate the expressions, a number of diagrams being given. The paper is not suitable for a short abstract. T. B.

1849. *The Isothermals of Some Gases up to* 400° *C. and their Significance for Gas-Thermometry.* **L. Holborn** and **J. Otto.** (Zeits. f. Physik, 23. 1–2. pp. 77–94, 1924. From the Reichsanstalt.)—This paper is an extension of previous work on the isothermals of gases used in gas-thermometry up to 100 atmos. pressure. In addition to nitrogen, oxygen, hydrogen, argon and helium, a mixture of neon and helium was used, and the temperature was extended up to 400° C. In the previous work [see Abstract 481 (1921)] a piezometer was employed, and the gas was contained in a glass vessel, but this was now discarded, and a steel tube of about the same capacity was used. This permitted a much smaller temperature-bath to be used, as it was strong enough to enable an external pressure equal to the internal pressure to be dispensed with. The steel tube was connected by means of a steel capillary tube with the rest of the apparatus previously used. The steel-containing tube was heated by an oil-bath for temperatures of 150° C. to 200° C., and in a bath of potassium nitrate for temperatures between 300° C. and 400° C. The baths were heated electrically and were provided with a stirrer. The results of the investigation are given in twenty tables, as well as the calculated pressure and expansion coefficients. Finally, curves are given for the initial inclination of the isothermals, *i.e.* curves with $\left(\frac{d(pv)}{dp}\right)_{p=0} . 10^5 = \mathrm{B} . 10^5$ as ordinates and temperatures as abscissæ. The values of $\mathrm{B} . 10^5$ are also calculated and tabulated, and the results used to calculate the corrections necessary for the constant pressure and constant volume gas-thermometers in order to reduce the readings to the thermodynamic scale. For temperatures below 0° C. the results obtained at the Leiden Laboratory are included.

T. B.

1850. *The Equation of State and the Compressibility of Mercury.* **K. K. Järvinen.** (Zeits. phys. Chem. 109. 3–4. pp. 275–286, 1924.)—In a previous paper (Zeits. phys. Chem. 97. p. 445, 1921) an equation of state has been suggested for mercury of the form $p = k \frac{v^{\frac{1}{3}}}{v^{\frac{1}{3}} - b^{\frac{1}{3}}} \cdot \frac{\mathrm{RT}}{v} - \frac{a}{v^{2\cdot 5}}$. Knowing the value of the constants, the compressibility of mercury is calculated as about $1\cdot 5 + 10^{-6}$. This agrees with the experimental values of Öersted and Jamin, but differs from that of Regnault ($3\cdot 7 \times 10^{-6}$). In consequence of this discrepancy, the methods of finding compressibilities are discussed, and it is concluded that the mathematical basis of Regnault's method is wrong. In this method it is assumed that when the liquid in the piezometer is submitted to equal internal and external pressure, the volume of the vessel diminishes to exactly the same extent as it would do if it were solid glass. The present paper suggests that no such diminution occurs, and the point is verified experimentally, using a rubber ball full of water. Taking data obtained by Metz, it is shown that on the basis of Regnault's ideas $\mathrm{B} = 3\cdot 7 \times 10^{-6}$, whereas on the assumption that the volume of the piezometer is unchanged $\mathrm{B} = 1\cdot 2 \times 10^{-6}$. The paper concludes with a discussion of some further points in connection with the equation of state.

A. A. D.

1851. *The Thermodynamics of Thermal Transpiration and of the Thomson Effect.* **E. H. Kennard.** (Phys. Rev. 22. pp. 617-621, Dec., 1923.)—*Thermal Transpiration.*—One can obtain an apparent violation of the Second Law by means of thermal transpiration, constructing an engine with an apparent efficiency of 50 per cent. for small ranges of temperature. But in reality the thermal effusion of a gas and the conduction of heat through it are merely two aspects of a single process, and when the degradation of heat due to conduction is taken into account the apparent violation disappears.

The Thomson Effect.—An analogous phenomenon in connection with the diffusion of electrons in a metal requires a slight modification of the formula obtained for the Thomson effect from the electron theory; the thermoelectric law deduced from equilibrium thermodynamics is then found to hold only because these effects in the two branches of the circuit cancel each other. If the current in reality is not carried entirely by electrons, or if one branch of the circuit is made to consist of an electron gas, then the effect should become noticeable. Hence conclusions drawn from equilibrium thermodynamics in such cases must be regarded as essentially tentative. AUTHOR.

1852. *A Supposed Limitation of the Second Law of Thermodynamics.* **J. W. Fisher.** (Phil. Mag. 47. pp. 779-781, April, 1924.)—Witmer has recently shown [see Abstract 909 (1924)], by a detailed analysis, the fallacy existing in Fairbourne's proof of a limitation of the Second Law of Thermodynamics [see Abstract 2110 (1922)]. The idea was that vessels of certain shapes immersed in a gas, where the mean free path is large in comparison with the dimensions of the vessels, might cause a motion of the gas to take place in one preponderating direction. Witmer shows that this would not occur for the vessels dealt with by Fairbourne by working out in detail the paths of the reflected gas molecules. It seems worth while, however, to point out that the same may be proved generally for a vessel of any shape whatever. This is done in the present paper for a vessel the walls of which are smooth but otherwise of arbitrary curvature. It is pointed out also that the argument here applied may easily be extended to the case where singularities occur in the surface such as sharp edges or points, and so the result is perfectly general. A. E. G.

SOUND.

1853. *Tuning-Forks.* **C. C. Mason.** (Journ. Sci. Instruments, 1. pp. 250–251, May, 1924.)—The importance of perfect symmetry of balance as between the two prongs of a tuning-fork does not seem to be realised. Various tests for perfection of balance are described. If a perfectly balanced fork could be obtained, the variation of frequency with amplitude and other conditions would probably be less marked than is ordinarily the case. If the fork is well balanced, the weight of its stand is immaterial.

G. A. S.

1854. *Æolian Tones.* **E. G. Richardson.** (Phys. Soc., Proc. 36. pp. 153–165; Disc., 165–167, April, 1924.)—After an account of previous work on the vibrations maintained by fluid motion, new experiments are described for testing by several methods the dependence of the pitch n on the fluid speed V and on the diameter D of the vibrator. The results show that V/nD varies from 8 to 5, while D ranges from 0·02 to 2 cm., the same figures being obtained with fluids of widely different viscosities. Results are also given for cords of square section, and a value of the critical speed for turbulence is deduced.

G. A. S.

1855. *Critical Frequency of Pulsation of Tones.* **F. Allen.** (Phil. Mag. 47. pp. 941–944, May, 1924.)—In a recent paper with above title [see Abstract 916 (1924)], several relationships were deduced from the experimental data connecting (1) D, the duration of a pulse of sound at the critical frequency of pulsation or flutter of a tone; (2) P, the blowing pressure of the air in tonvariator, to which the intensity of the sound is proportional; and (3) N, the frequency of vibration of the tone. The most important of these relationships is that connecting D and P, viz.: $D = K\sqrt{(\log P)} - C$, where K and C are constants. This equation, applied to the experimental data, gave a series of straight lines for different values of N. These lines were so uniformly straight that it was concluded that this equation completely satisfied the experimental data.

The analogous equation of T. C. Porter connecting (1) D, the duration of a flash of light at the critical frequency of the flicker, and (2) L, the intensity of illumination of a black and white disk, is $1/D = K \log L + C$. And this equation, when applied to Porter's experimental data for white light, was found to have two values for the constant K, and therefore represented two straight lines with different inclinations, which met at a point representing the low illumination of a ¼-metre candle. As this peculiarity of Porter's law has been interpreted as applying to vision by the rods for dim light, and by the cones for bright, there seemed no reason for the occurrence of a similar phenomenon in the perception of sound, since nothing suggestive of a double percipient mechanism corresponding to rods and cones is known to exist in the ear.

But recent unpublished work in the present author's laboratory on the sense of touch revealed a phenomenon of double action precisely similar to Porter's law for the visual sensation. In consequence of this discovery, the data on sound were re-examined. On plotting the values of D and log P, it was found that each graph consisted of *two* straight lines similar to those found by Porter. The change in slope of the lines in the figure occurs in each case at an intensity given by the tonvariator when blown by an air-pressure of 1·70 cm. of water. This is a quite weak sound, and is comparable with the analogous point found by Porter for light. The larger value of K in Porter's equation is for high intensities, whereas the opposite is the case with sounds. But Porter's equation expresses the reciprocal of D, while the sound equations give D directly.

Thus, the Porter effect appears to be a general property of the sensory nervous system, and hence must be referred to some fundamental property that all such nerves possess in common. It is thought that the most probable location of the effect is in the synapses, which Sherrington has found to possess a large number of important functions in nerve conduction.

E. H. B.

1856. *Telephonic Excitation of Acoustic Pressure.* **C. Barus.** (Nat. Acad. Sci., Proc. 10. pp. 96–99, March, 1924.)—The author previously described [Science, 24. p. 155 (1921)] a series of simple experiments bearing on the nature of the acoustic forces observed in connection with telephone-blown pipes. On testing this work recently it was found that a series of repulsions occurred as well as the former attractions. The arrangements used in the experiments are explained by diagrams, and the forces of repulsion and attraction are represented by graphs. E. H. B.

1857. *Audible Sonic Beats from Inaudible Sources.* **R. W. Boyle, S. C. Morgan** and **J. F. Lehmann.** (Roy. Soc. Canada, Trans. 17. Sect. 3. pp. 141–145, 1923.)—Two ultra-sonic "oscillators," of the type first used by Langevin, excited from two separate electrical sources, were placed facing one another in a large tank of water at a distance of 60 cm. Thus the two ultra-sonic beams, given out perpendicular to the faces of the oscillators, were made to intermingle. The oscillators were excited by electric oscillations of the required adjustable frequencies, generated by electronic valves in the usual manner. Two independent sources of electrical energy were employed; one, an alternating potential of 60 cycles per second, producing a "tonic train" of ultra-sonic waves when applied to an ultra-sonic oscillator, and the other a continuous potential producing "continuous" ultra-sonic waves. Although ultra-sonic waves are themselves inaudible, a listening device can detect an ultra-sonic beam if the source of electrical energy applied to the valves generating the high-frequency electrical oscillations is a rectified alternating e.m.f. The group-frequency of the resulting tonic train is then twice the frequency of the alternating source. A good listening device was constructed by cementing two very thin mica discs to the sides of a brass washer 0·5 cm. thick, and with a hole 1·4 cm. in diameter, and connecting a stethoscope to a small brass tube soldered radially into the brass washer. When this listening arrangement was moved about in the space between the two oscillators immersed in water, a musical beat note was heard at once if the difference of the ultra-sonic frequencies was in the range of audibility. When one transmitter only was in use, with continuous waves, nothing was heard in the stethoscope, but when 60-cycle a.c. was used a note of 120 cycles per second—the tonic train group frequency—was heard, and when both transmitters were excited from the a.c. source the beat note and the tonic train note were both heard. As the listening device was moved along the axes of the two intermingling beams, positions of maximum and minimum intensity of the beat note could be observed, indicating the presence of stationary waves. These maxima and minima were a half-wave-length apart, the half-wave being about the average of the halves of the individual waves, which were nearly equal. A. W.

1858. *Auditory Masking of One Pure Tone by Another and its Probable Relation to the Dynamics of the Inner Ear.* **R. L. Wegel** and **C. E. Lane.** (Phys. Rev. 23. pp. 266–285, Feb., 1924.)—Using an air-damped telephone receiver supplied with current with a proper combination of two frequencies, as source, the amount of masking by tones of frequency 200 to 3500 was determined for frequencies from 150 to 5000 per sec. The magnitude of a tone is taken as the logarithm of the ratio of its pressure to the threshold value, and masking is taken as the logarithm of its threshold value with masking to that without. The curves of masking as function of magnitude are approximated straight lines as a rule, except for rounded feet, of slope *s* intersecting the magnitude axis at minimum masking magnitude *m*. For a given masking frequency *n* the slope increases from zero through nearly unity for a frequency near *n*, then more slowly, approaching about three or four for the highest frequencies measured. The intercept is small or zero below *n*, then increases rapidly, approaching the value three for high frequencies. Except when the frequencies are so close together as to produce beats, the masking is greatest for tones nearly alike. When the masking tone is loud it masks tones of higher frequency better than those of frequency lower than itself. When the masking tone is weak there is little difference. If the masking tone is introduced into the opposite ear, no appreciable masking occurs until the intensity is sufficient to reach the listening ear through the bones of the head. At intensities considerably above minimum audibility, there is no longer a linear relation between the sound pressure and the response of the ear. Data are given showing *combinational tones* resulting from this *non-linearity* when two tones are simultaneously introduced in the ear. The presence also of *subjective overtones* in a loud tone accounts for the large amount of masking of tones higher than itself by a loud masking tone.

The data on masking together with Knudsen's data on frequency sensibility are interpreted in terms of the *dynamical theory of the cochlea*, which ascribes its frequency selectivity to a passing of vibrations along the basilar membrane and a shunting through narrow regions of the membrane at points depending on the frequency. Conjectured curves are given for a few single frequencies of the amplitude of vibration of this membrane as a function of the distance along it. [See Abstract 1244 (1924).] E. H. B.

1859. *Vibration in Spark-Blown Closed Quill Tubes by Electric Oscillation.* **C. Barus.** (Nat. Acad. Sci., Proc. 10. pp. 1–3, Jan., 1924.)—The present experiments are in the main similar to the preceding ones on the vibration of the air filament in quill tubes closed at both ends, except that the vibration is now maintained by a spark succession of controllable frequency instead of by a telephone. [See Abstract 2228 (1923).] The results obtained here are in fair agreement with the former ones. The resonance conditions as before, are determined by the acoustic pressures generated, these being measured by the interferometer U-tube. The acoustic pressure appears to be proportional to the length of the spark-gap. The electric oscillations produced in one tube are also examined, the frequency of the primary break being maintained constant, whilst that of the secondary is modified by means of a variable condenser. From these results an approximate value for the inductance of the secondary is deduced. A. A. D.

1860. *Physical Criterion for Pitch of a Musical Tone.* **H. Fletcher.** (Phys. Rev. 23. pp. 427–437, March, 1924.)—A high-quality telephone system was used to reproduce musical sounds from the voice, the piano, the violin, the clarinet and the organ without any appreciable distortion. Into this telephone system electrical filters were introduced which made it possible to eliminate any desired frequency range. Results with this system show that only the quality and *not the pitch* of such musical sounds changes when a group of *either the low* or high-frequency components is eliminated. Even when the fundamental and first seven overtures were eliminated from the vowel *ah* sung at an ordinary pitch for a baritone, the pitch remained the same. These results were checked by a study of synthesised musical tones produced by ten vacuum-tube oscillators, with frequencies from 100 to 1000 at intervals of 100. It was found that *three consecutive component* frequencies were sufficient to give a clear musical tone of definite pitch corresponding to 100, and that in general, when the adjacent components had a *constant difference* which was a *common factor* to all components, a single musical tone of pitch equal to this common difference was obtained, but not otherwise.

Recent work on hearing has shown that the transmission mechanism between the air and the inner ear has a non-linear response, which accounts for the so-called subjective tones. When the components of low frequency are eliminated from the externally impressed musical tone, they are again introduced as subjective tones before the sound reaches the nerve terminals. Calculation of the magnitude of these subjective tones from the non-linear constants of the ear shows that the results on pitch are what might be expected.

Sound spectra of ten typical musical sounds, obtained with an electrical harmonic analyser to be described by Wegel and Moore, are given in the present paper for *ah* sung at pitch *d*, *ā* sung at *a*, the notes c_1 and c' on the piano, g' on the violin, c on the clarinet, also c_1 (at three pressures) and c' on organ pipes. E. H. B.

1861. *Production of Tone in Blown Pipes.* **P. Cermak.** (Phys. Zeits. 25. pp. 121–130, March 15, 1924.)—This paper records a number of experiments in continuation of previous work [see Abstract 717 (1923)]. It is found that if a pipe has one or several discs in it, each pierced by a hole at its centre, blowing will elicit a tone. The frequency of the excited tone increases with increased blast, but the tones elicited are only the fundamental resonance tone of the pipe and its overtones. It has been investigated how the positions of the discs, their thickness and the sizes of their holes influence the production of the tone. The utterance of the tone was found to depend on the formation of eddies at the edge of the holes in the discs. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1862. *Effect of a Transition Layer on Intrinsic Potential.* **P. V. Wells.** (Phys. Rev. 23. pp. 205–208, Feb., 1924.)—Frenkel's theory of the intrinsic potential is generalised to include the effect of a transition layer. The expression derived is $\phi = 2\pi n\Sigma(\overline{Er^2 \cos^2 \theta})$, where n is the number of molecules per c.c., and the summation is made of the mean square normal component distances of the electrons and nuclei from the centre of mass of the molecule, one term for each electron and one for each nucleus, E being the corresponding charge. The intrinsic potential depends, then, on the average positions of the electrons and nuclei, but is independent of the form of the transition layer. For molecules with spherical symmetry the expression reduces to that of Frenkel. AUTHOR.

1863. *Relation between the Potential Gradient and the Number of Large Ions in the Atmosphere.* **J. J. Nolan.** (Nature, 113. p. 493, April 5, 1924.)—The author's experiments have shown that there is often a close connection between the magnitude of the atmospheric potential gradient and the concentration of large ions, and three examples are given, two showing the similarity between the curves representing the simultaneous variations of the quantities during two different intervals of an hour each, and one showing the similarity between the curves representing the simultaneous variations in the daily means of the quantities over an interval of three weeks. There are cases, however, when the agreement is not so good. The concentration of ions of one sign only is used, but in the author's experience it is exceptional for there to be any great difference between the numbers of ions of the two signs. It is suggested that the connection demonstrated is not direct, but that a large number of large ions implies a small number of the more mobile small ions, and therefore an increased resistance in the lower layers of the atmosphere and a steepening in the potential gradient. The possible effect on measurements of the potential gradient in the neighbourhood of cities is mentioned.

M. A. G.

1864. *Atmospheric Discharge of Globular Form.* **G. F. Vandeperre.** (Elettrotecnica, 11. pp. 271–273, April 25, 1924.)—This paper contains accounts of some instances in which the author has observed the curious phenomenon of ball lightning. A. E. G.

DISCHARGE AND OSCILLATIONS.

1865. *Electricity in Flames.* **H. A. Wilson.** (Am. Electrochem. Soc., Trans. pp. 44. 127–136, 1923.)—An historical review is given of the work of Giese in 1882 in developing the ionic theory of gaseous conductivity and of the work of Arrhenius in 1891 on the conductivity of the Bunsen flame containing salt vapours whereby the relation was established between the current, p.d., and distance between the electrodes and concentration of salt vapour in the flame. It is found by the present author that for flames of equal conductivity containing different alkali metals, the relation between the current, p.d., and distance between the electrodes is nearly the same, from which it follows that all alkali metals give ions having the same ionic mobilities. In accordance with the mobility of the negative ion being greater than that of the positive, it is found that the potential gradient is greater near the negative electrode than near the positive. The percentage of vapour ionised in a Bunsen flame varies from 91 in the case of cæsium to 0·2 in the case of lithium. The velocity of the negative ions due to 1 volt per cm. in a Bunsen flame appears to be between 1000 and 20,000 cm. per sec. with a probable value of about 7000 cm. The velocity of the positive ion with the same gradient appears to be only 1 or 2 cm. per sec. The negative ions are probably free electrons part of the time and combined with neutral atoms the remaining time. An investigation has been made of the ionisation by collision of the electrons with alkali atoms which occurs when using strong electric fields. An account is given of the behaviour of flames in a magnetic field, and a discussion is given of the application of thermodynamical theory to the calculation of the degree of ionisation at high temperatures. It is found that the ionisation of alkali metals in flames is approximately in accordance with Saha's theory [Abstract 218 (1921)], or a nearly constant value is given by the product of the relative concentrations required to give equal conductivities in a flame with the relative degree of dissociation as calculated from the expression :—

$$\log_{10} \frac{K_2}{K_1} = \frac{5048 \, (V_1 - V_2)}{T}$$

where K_1 and K_2 represent the dissociation values, V the ionisation potential, T the absolute temperature, and 5048 is derived from the charge on the electron.

A bibliography is given of the literature on the subject. J. N. P.

1866. *The Conductivity of Flames for Rapidly Alternating Currents.* **H. A. Wilson** and **A. B. Bryan.** (Phys. Rev. 23. pp. 195–199, Feb., 1924.)—Expressions are developed for the capacity and series resistance of a parallel plate condenser in a salted flame, which enable certain constants to be computed from the measurements of Bryan [see next Abstract]. The calculated density of positive ions increases from 0·03 e.s.u. in the unsatled flame to 1·5 e.s.u. for the flame sprayed with a solution of 10 grammes/litre K_2CO_3. For the smaller concentration, it varies about as the square root of the potassium present, as was to be expected. The variation with frequency and electric field is slight. The calculated mobility of electrons is found to diminish from 200 to 60 m./sec. per volt/cm. as the r.m.s. field increases from 9 to 64 volts/cm., in good agreement with values found by Loeb for electrons in pure nitrogen at room temperatures. It decreases markedly as the concentration of potassium increases. AUTHORS.

1867. *The Electrical Properties of Flames containing Salt Vapours for High-Frequency Alternating Currents.* **A. B. Bryan.** (Phys. Rev. 23.

pp. 189–194, Feb., 1924.)—The capacity C_1 and equivalent series resistance R_1 of a condenser consisting of two concentric platinum cylinders, 0·5 cm. apart, in a flame containing K_2CO_3 vapour, are measured, using a modification of the method of resistance variation. Values of C_1 and R_1 are obtained for voltages between 11·4 and 82·2 volts, for frequencies between 2×10^5 and 10^6 cycles per second, and for salt concentrations up to 10 grammes per litre of K_2CO_3 solution. The resistance is approximately independent of the field, but decreases somewhat as the frequency increases and also as the concentration increases. The capacity is half as great for 82 as for 11 volts, and for 10×10^5 as for 2×10^5 cycles, but increases fivefold as the concentration increases from 0·1 to 10 grammes per litre. The apparent dielectric constant varies from 1·2 for the unsalted flame to 9·1 for 10 grammes per litre.

[For theoretical discussion see preceding Abstract.] AUTHOR.

1868. *The Motion of Electrons in Nitrogen.* **H. B. Wahlin.** (Phys. Rev. 23. pp. 169–177, Feb., 1924.)—Mobilities of electrons in nitrogen have been determined in fields ranging from 1 volt/cm. to 55 volts/cm. at atmospheric pressure. For low fields the mobility has a value of 18,000 cm./sec., but decreases rapidly for higher fields. The results agree for low fields with Compton's mobility equation, *viz.*, $u = a/[1 + (1 + Bx^2)^{\frac{1}{2}}]^{\frac{1}{2}}$, but in order to obtain full agreement it must be assumed that the mean free path of the electron decreases as the velocity of the electron increases, and also that the impacts of electrons with nitrogen molecules are not completely elastic. The mean free path of the electrons in nitrogen at a pressure of 760 mm. and in thermal equilibrium with the molecules has been determined from the limiting mobility as the field in which the mobility is determined approaches zero. The value thus found is 0·000131 cm. This is about 2·7 times the kinetic theory value. AUTHOR.

1869. *Electron Emission from Metals as a Function of Temperature.* **O. W. Richardson.** (Phys. Rev. 23. pp. 153–155, Feb., 1924.)—The equation $i = AT^2\epsilon^{-b_0/T}$ was first presented in 1911, and the fact that A is a universal constant was stated in 1915. The proof involved nothing beyond the application of elementary thermodynamics to the equilibrium of the external electron atmospheres, hence the development owes nothing to Nernst's heat theorem or chemical constants. Contrary to Dushman's implication [Abstract 310 (1924)], the writer did not consider it probable that the work function is the same for all substances. AUTHOR.

1870. *The Emission of Electrons under the Influence of Chemical Action.* **M. Brotherton.** (Roy. Soc., Proc. 105. pp. 468–480, April 1, 1924.)—An extension is made of the earlier investigation of O. W. Richardson [Abstract 1593 (1921)] of the emission of electrons from drops of a liquid alloy of sodium and potassium when acted on at a low pressure by chlorine, carbonyl chloride, and water-vapour. The experimental method adopted is similar to that employed in the earlier work. Two methods of supplying the active gas at high and low pressures respectively to the alloy are devised, which render it possible to secure an emission varying by less than 20 % in 60 mins. The saturation currents range from $2 \cdot 0 \times 10^{-10}$ amps. to $4 \cdot 3 \times 10^{-8}$. The magnitude of the emission is dependent both on the rate of the drops and on the pressure of the active gas. At low pressures the shape of the curve giving the relation between current and voltage is dependent mainly on the pressure of the active gas, and independent of the composition of the alloy and the rate of the drops. The curve approaches the voltage axis in the region of 1 volt. Saturation invariably occurs within 3·5 volts and sometimes less. The saturation part of the curve is parallel to the voltage axis up to 15 volts, beyond which it is not examined at low pressures.

With increase of pressure of the active gas an increase is obtained of the saturation current and of the potential required to cause saturation, while the saturation part of the curve assumes an upward slope which is particularly marked beyond a certain potential. With a reading of 2 mm. pressure on a gauge containing sulphuric acid, the saturation part of the curve has almost disappeared and the graph becomes nearly a straight line up to 40 volts. The approach of the current curve to the voltage axis is found to be gradual and appears to be asymptotic. In this respect the chemical characteristic is differentiated from the photo-electric curve and resembles the thermionic relation. J. N. P.

1871. *Behaviour of Low-Velocity Electrons in Methane Gas.* **G. Glockler.** (Nat. Acad. Sci., Proc. 10. pp. 155–160, April, 1924.)—The curve obtained by plotting values of the current as ordinates against values of the applied voltage as abscissæ, in the case of methane contained in a three-electrode tube exhibits a well-marked maximum. This maximum is shown to be attributable neither to dissociation of the gas nor to its thermal decomposition by the hot filament, but may be due to a low radiation-potential of the gas or to abnormal transparency of the gas as regards low-velocity electrons. J. S. G. T.

1872. *Effective Radii of Gas Molecules.* **L. L. Nettleton.** (Nat. Acad. Sci., Proc. 10. pp. 140–145, April, 1924.)—When electrons pass through a gas and produce ions, the number of these is directly proportional to the gas pressure, to the number of electrons, and to the distance they travel. When all these factors are constant, the number of ions produced decreases with increasing velocity of electrons. If the effective molecular radius is defined as the radius of a sphere about the molecular centre, within which (on the average) an electron must pass to ionise the gas molecule, this decrease in ionisation may be interpreted as a decrease of the effective molecular radius. The change in ionisation as a function of the velocity of the ionising electrons is the subject of the present investigation. The apparatus used is described in detail and is very similar to that of Barber and McAllister [Abstract 1132 (1921) and 1438 (1923)] for the study of secondary electron characteristics. Measurements were made for air, hydrogen, and mercury-vapour over a range of electron velocities from 100 to 2500 volts. The results are shown in curves where the effective molecular radius is plotted against the electron velocity, from which is seen a regular decrease of the effective molecular radius with increasing electron velocity. This suggests that the change in the ionising power of electrons may be in accord with the Rutherford relation that the ionisation $I = K^1/E^{\frac{1}{2}}$, where E is the electronic energy and K^1 a constant. The corresponding relation in terms of electron velocity, v, and molecular radius, a, is $a = K/V$. To test this further, the data of other workers on ionisation in air due to electrons, kathode rays, and β-rays were reduced to the basis of effective molecular radius, when over a range of velocities from 10^8 to $2 \cdot 5 \times 10^{10}$ cm. per sec., the ionisation is in general agreement with Rutherford's formula.

H. H. Ho.

1873. *Ionisation and Activation of Gases.* **K. T. Compton.** (Am. Electrochem. Soc., Trans. 44. pp. 117–125; Disc., 125–126, 1923.)—During the passage of an electric discharge through a gas the atoms are not all in the normal state, but exist in a great variety of conditions of partial or complete ionisation, each state having its own characteristic physical and chemical properties. The following effects of some of these properties are important: Formation of unusual temporary chemical compounds; spectroscopic changes, especially in the band and absorption spectra; production of arcs at abnormally low voltages; catalytic action of a gas whose atoms are in an excited state upon another gas with which it is mixed. This catalytic action may be a photochemical action or not, depending on whether light or another agent is used to put atoms into the excited state.

AUTHOR.

1874. *The Formation of Gaseous Ions in the Oxidation of Nitric Oxide.* **A. K. Brewer and F. Daniels.** (Am. Electrochem. Soc., Trans. 44. pp. 257–268; Disc., 268–269, 1923.)—Experiments with a special form of chamber show that when nitric oxide is oxidised between oppositely charged electrodes a current of electricity passes through the gases. The current is of the order of 10^{-14} amp. for the oxidation of 50 c.c. of nitric oxide per minute reacting in a field of 450 v. per cm. This corresponds to about one ion for every 10^{13} molecules reacting. The current is directly proportional to the voltage and to the number of molecules reacting. No evidence of a saturation current could be detected. The precautions necessary to exclude extraneous charges and obtain reproducible results are given. Various hypotheses are advanced to explain the results.

AUTHORS.

1875. *Electron Emission from Plates Bombarded by Positive Ions.* **E. Badareu.** (Phys. Zeits. 25. pp. 137–140, March 15, 1924.)—The chief difficulty in investigating the electron emission from a metal subjected to the bombardment of positive ions in a high vacuum is that the number of ions in the bombarding stream normally increases with the electric field. An arrangement is here described in which this is obviated. Using a heated platinum kathode, it is shown that, contrary to the opinion of Stark, it is unnecessary for the bombarding ions to possess a certain threshold energy, but that electron emission takes place for all energies of the ions, and, in fact, that the number of electrons emitted is proportional to the energy of the ions. Further experiments using different metals are contemplated.

G. A. S.

1876. *The Spectrum Emitted during the Stoppage of the Positive Rays of Lithium.* **M. Morand.** (Comptes Rendus, 178. pp. 1528–1529, May 5, 1924.)—A continuous stream of positive rays of lithium has been obtained, and it is found that when a bundle of these rays strikes an obstacle they form a thin layer of the metal, the process corresponding to a true "electrolysis." The region in which this layer is formed is luminous during the action and the light emitted is characteristic of the positive rays used. Thus the light sent out shows the usual lithium lines, that is, the arc spectrum emitted by the neutral atom. The explanation is very simple, namely the capture of electrons by the positively charged rays, the electron in falling into its stable orbit emitting the characteristic spectrum. Lines corresponding to various impurities, including silicon, have been observed. Three other lines have also been noted, including 2934·15 attributed by Mohler to the spark spectrum of lithium. These may arise from the bombardment by the oncoming and powerfully ionising lithium positive rays of a "cloud" of lithium which surrounds the kathode. The line 2934·2 may be a doublet with components 2933·85 and 2934·5, and if so this is important, for the spark spectrum of lithium must be comparable with that of helium and one might expect to find a line in this region corresponding to the helium doublet 10829·1–10830·3. The author has also observed λ3715·4 and 2498·1 apparently belonging to the spark spectrum of lithium. W. V. M.

1877. *The Spectra Associated with Thermionic Discharge in Carbon Monoxide.* **F. Baldet.** (Comptes Rendus, 178. pp. 1525–1527, May 5, 1924.)—The study of the spectra due to thermionic discharge is as interesting to astro-physicists as to pure physicists, since to the former the method is valuable in researches on the spectra of comets, nebulæ, etc.

A diode has been used containing carbon monoxide under low pressures of a few tenths of a millimetre and having a fall of potential of about a hundred volts, under which conditions a complex band spectrum was produced consisting of the spectra due to "carbon monoxide" (or second positive group), the third positive group, an ultra-violet negative group due to carbon, a doublet spectrum observed in comet's tails and identified by Fowler [Abstract 367 (1910)] with low-pressure CO, and an apparently new spectrum. At lower pressures the spectra of comet's tails are remarkably reproduced. The introduction of a little air causes the appearance of "cyanogen" bands and the negative nitrogen group at 3914. The new spectrum is well developed under a pressure of 0·7 mm. and less visible at 10 mm. It consists of three intense doublets shading off towards the violet, each head of which is itself a close doublet. The appearance is similar to that observed in comets' tails the bands being formed of numerous lines only resolved at high power. This spectrum cannot with certainty be attributed to carbon monoxide. W. V. M.

1878. *Electron Emission from Metals as a Function of Temperature.* **S. Dushman.** (Phys. Rev. 23. p. 156, Feb. 1924.)—Recent very accurate measurements on the emission from filaments suggest that the constant A has the same value for all pure crystalline substances such as pure W, Mo and Ta, but is less for thoriated tungsten, cæsiated tungsten and oxide-covered platinum. This apparent disagreement with theory is briefly discussed. [See Abstract 310 (1924).] AUTHOR.

1879. *Law and Mechanism of the Emission of Electrons from Hot Bodies.* **S. C. Roy.** (Phil. Mag. 47. pp. 561–569, March, 1924.)—On the supposition that the electrons inside a metal form space-lattices just as atoms do in a crystal, and regarding the thermal emission of electrons from metals as thermodynamically equivalent to a process of sublimation from the solid to the gaseous state, a mathematical expression for the thermionic current-density is obtained, the argument involving the employment of various recent theorems. The distinction between photo-electrons and thermally emitted electrons is discussed in relation to the general question of electron emission. A. B. C. L.

1880. *Emission from an Incandescent Platinum Wire in Air.* **A. M. Tyndall and G. C. Grindley.** (Phil. Mag. 47. pp. 689–702, April, 1924.) —The mobility of the normal ions produced by the usual ionising agencies in fairly dry, dust-free air at atmospheric pressure is of the order of 1·8 cm./sec./volt/cm. for negative and 1·4 for positive ions. An apparent exception to this was found by McClelland in the case of ions from an incandescent wire, an arc, or a flame. In his experiments an air current carried the ions into a metal tube, in which their mobility was determined by a method which Rutherford had used in the case of ions produced by uranium. In the case of an incandescent wire, with which the present paper is concerned, McClelland found that the ionic mobility was small compared with that produced by X-rays, and that the hotter the wire the smaller was the mobility. Further the mobility, which was of the order of 0·01 to 0·003 cm./sec., decreased with increase of distance from the source. McClelland concluded that each ion picked up molecules and formed a cluster which grew in size with age. Rutherford made observations on the current between two plates, one of which was red hot; he concluded that the mobility of the positive ions from platinum may vary within wide limits, its average value decreasing with increasing distance between the plates. The purpose of the present experiments is to obtain more definite information on the whole subject by means of mobility measurements. Two types of apparatus are used, the first suggested by an experiment of Nolan, though differing from it in several respects, and is here referred to as the box method; the second is McClelland's original method with modifications. Both are described and illustrated diagrammatically. The conclusion drawn from the experiments described is that the hot filament emits electrons, positive ions, and a copious supply of uncharged particles. When removed from the vicinity of the particles, the electrons attach themselves to molecules and become normal ions of mobility the same as that of negative ions produced by polonium. In the first method the mobility is measured within ⅓ of a sec. from birth and in the second method after 5 to 15 secs. with the same results, showing that, removed from nuclei, the "normal" ion retains its identity unchanged with age. The positive ions are complex. Curves showing results strongly suggest that positive ions of mobility about 1·4 in air are given off from the hot wire, but there must also be many ions present having mobilities from 20 to 60 per cent. lower than this. Hütterman has shown that *in vacuo* a hot wire emits not only gaseous positive ions but positive atoms of the metal, and the curve given here may be accounted for in this way. It is, however, a little doubtful whether a mobility of the order of 1·1 instead of the normal 1·4 could be that of foreign gaseous ions or of platinum atoms in air. Blanc has carried out some work which suggests that the mobility of the CO_2 ion measured in air is the same as that of an air ion. Similar results have been obtained by Wellisch for ions of methyl iodide in an atmosphere of hydrogen. Franck arrives at the same conclusion in the case of the positively charged recoil atoms of thorium D. If these results are accepted it must be concluded that the positive ions are emitted either as small metallic clusters or as atoms, many of which form clusters by the time they reach the box. The clusters, however, must be small compared with those usually known as large ions. The wire when used

for positive emission was only at dull red heat; the convection current from it was therefore less than when it was negative. A certain amount of clustering of ions with uncharged nuclei may possibly, therefore, have taken place before they were separated. The emission of the negative ion as an electron with high mobility, together with the greater convection current would account for the absence of similar clustered ions in the results for negative discharge. The uncharged particles are presumably metallic clusters ranging in size from atoms to metallic dust. Left in association with ions, they take up charges and become large ions.
A. E. G.

1881. *Angular Momentum and Electron Impact.* **P. M. S. Blackett.** (Cambridge Phil. Soc., Proc. 22. pp. 56–66, Feb., 1924.)—A mathematical investigation of the assumption that, in a system consisting of one atom and one impacting electron, there is exact conservation of both energy and linear and angular momentum. It is shown that, for electron energies just greater than the excitation energy, it is possible to derive from this assumption an upper limit to the probability of excitation by electron impact. The effect of the quantum orientation of the atoms in a magnetic field is shown to impose important restrictions on the conditions for excitation, and the predicted probabilities are shown to be in rough agreement with some results of Franck.
A. B. C. L.

1882. *The Free Potential of the Grid and Plate of the Triode Valve and the Apparent Distribution of the Initial Velocity of Electrons.* **H. Nukiyama** and **T. Kuwashima.** (Inst. El. Eng. of Japan, J. No. 425. pp. 942–949, Dec., 1923.)—Measurements were made by means of a quadrant electrometer. The free potential of the grid was found to be negative in most cases, even if the plate voltage is kept high by an external source of e.m.f. The effect of a grid leak on the free potential of the grid was studied in detail, and from this investigation the apparent distribution of the initial velocity of electrons was calculated.
W. R. C.

1883. *The Photoelectric Effect.* **R. Dümpelmann** and **W. Hein.** (Zeits. f. Physik, 22. 6. pp. 368–383, 1924.)—H and O, developed on the hinder side of an iron plate, enhance the photoelectric effect considerably. When their evolution is stopped, the photoelectric effect falls off quickly. This is not due to the gases diffusing through the metal, renewing the surface, and removing the photoelectric fatigue; a well-scrubbed surface is equally sensitive to this enhancement. Besides, fatigue is long in showing itself, and the action of H or O is prompt. Again, the result is not due to changes of temperature. It is mainly due to alteration of the iron by its becoming permeated with the gases. Copper absorbs very little H or O, and there is little or no change in the photoelectric effect. Hydrogen acts in the same manner, whether electrolytically or chemically formed. Light decreases the photoelectric effect, which is regained in darkness; the regain in darkness is greater the more the iron is charged with H or O molecules.
A. D.

1884. *Symmetry of Incident and Emergent Photo-Electronic Velocities.* **R. J. Piersol.** (Phys. Rev. 23. pp. 144–152, Feb., 1924.)—Previous observers have obtained ratios of emergent to incident energies of 1·25 or more, contrary to quantum theory, but these ratios are shown to be due to the rounding off of the "feet" of the current voltage curves as a result of the presence of stray light of shorter wave-length. When monochromatic light was used and precautions were taken to avoid stray light, a photoelectric cell of the ordinary type with a thin Pt film deposited on glass as target, gave straight-line curves crossing the line of zero current at the same voltage point. Additional experiments showed that the maximum energy is the same in all directions and equal to 1·76 volts for 1850 Å, and 0·20 volt for 2540 Å. A. B. W.

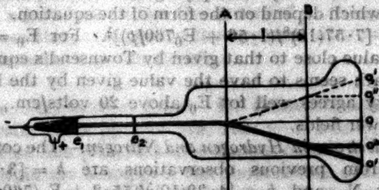
1885. *The Mobilities of Electrons in Helium.* **L. B. Loeb.** (Phys. Rev. 23. pp. 157–168, Feb., 1924.)—The results of measurements previously described on the mobilities of electrons in N_2 [see Abstract 984 (1922)] and H_2 [see Abstract 195 (1923)] at atmospheric pressures, using the Rutherford alternating current method with sine wave form oscillations, made it of interest to determine those in helium, in which Compton has shown that the fraction of the energy lost by an electron at each impact with a He atom lies close to the theoretical value $f = 2m/M = 0 \cdot 000268$ (m being the mass of the electron and M that of the He atom). The mobilities were determined for fields up to 50 volts/cm. and at pressures of 447, 189, 117 and 49 mm. of Hg. The He was purified by prolonged circulation over charcoal in liquid air, maintained by a mercury-vapour pump. Spectroscopic observation indicated the impurity to be about 1/10,000, chiefly H. The results for the mobility constant, reduced to 760 mm. pressure and computed in the ordinary way, are well represented by the equation $k' = [11 \cdot 0(10)^8/(2 \cdot 45 + E_0 760/p)]^{\frac{1}{2}}$, where $E_0 = v_0/d$ is the electric field as read on a static voltmeter. It has been pointed out that since k is a function of E_0, a correction is necessary because of the use of a varying field in the measurements. It is now shown that this correction may be made by multiplying the constants in the equation for k' by factors which depend on the form of the equation. The corrected equation is $k = [7 \cdot 57(10)^8/(1 \cdot 56 + E_0 760/p)]^{\frac{1}{2}}$. For $E_0 = 0$, this gives $k_0 = 22,000$, a value close to that given by Townsend's equation. Hence the mean free path seems to have the value given by the kinetic theory. Compton's theory agrees well for E_0 above 20 volts/cm., but gives too low values for lower fields.

Mobility of Electrons in Hydrogen and Nitrogen.—The corrected empirical equations from previous observations are $k = [3 \cdot 637(10)^5/(11 \cdot 9 + E_0 760/p)]$ for N_2 and $k = \{4 \cdot 32(10)^5/[55 \cdot 2 + E_0(760/p)^{\frac{1}{2}}]\}$ for H_2. Experimental procedure is very fully described. H. H. Ho.

1886. *Electrical Properties of Helium.* **J. S. Townsend** and **S. P. McCallum.** (Phil. Mag. 47. pp. 737–753, April, 1924.)—The authors claim that the experiments on the photoelectric electric currents in helium between parallel plate electrodes arranged in such manner as to determine the rate of increase of the current with the distance between the plates, have shown that the electrons set free from the negative electrode by ultra-violet light acquire sufficient energy to ionise molecules by collision before any other process of ionisation occurs to an extent which is appreciable in comparison with the effect of ionisation by single collisions [see Abstract 1198 (1923)]. They admit that results which follow by simple calculations from this theory are not in agreement with the properties of atomic models as indicated by the quantum theory. Detailed descriptions of experiments are given which are claimed as supporting the theory and as answering objections raised against it. G. W. DE T.

1887. *The Active Agents in Luminescent Calcites, Aragonites, and Dolomites.* **T. Tanaka.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 411–418, March, 1924.)—In his previous study of the kathodo-luminescence of solid solutions of 42 metals [see Abstract 1548 (1924)], the author determined the location of the luminescence bands characteristic of those metals, the frequency intervals of each one, and certain regular relations existing between these frequency intervals and the atomic weight. The results afford a principle by which the identity of a metal to which certain bands are known to be due can be ascertained, and thereby enabled the investigation of some luminescent substances the active agents of which have long been subjects of discussion. In the present paper the kathodo-luminescence of certain calcites and related minerals are considered, an historical review of previous work preceding the data now acquired. The chief active agent in the luminescence of calcites, crystalline limestones, and dolomites is found to be generally manganese, and the luminescent colour is orange or reddish-orange. Sometimes manganese does not show a prominent luminescent power and in such cases the luminescence is generally faint. Sometimes strontium acts as the chief active agent, giving a greenish, comparatively faint luminescence, such occurring frequently in aragonites. Other active agents are dysprosium, yttrium, thallium, and samarium. H. H. Ho.

1888. *Experimental Determination of the Velocity of Kathode Rays.* **F. Dacos.** (Assoc. Ing. El. Liége, Bull. 2. Ser. 7. pp. 105–115, March, 1924.)—The principle of the method employed is as follows: The kathode rays are filtered through two screens e_1 and e_2, the parallel beam of rays emerging produce at O on the side opposite the kathode a phosphorescent spot. This parallel bundle of rays is a flexible conductor. When a force of extremely short duration acts at A at the moment in which the ray passes there, it is deviated from the straight path—towards the base, for example—and the phosphorescent spot is displaced from O to O′. A time t is necessary for the deviated ray AO′ to cross the distance AB $= l$. If at the moment in which this ray AO′ penetrates into the zone B, it is submitted to a similar influence, but opposite to that at A, AO′ is then deviated upwards, and the phosphorescent spot tends to take up its initial position O and comes to O″. When the action at B takes place in exactly time t after that at A, the spot O″ approaches closest to O. The velocity v of the kathode rays is then expressed by the simple relation $v = l/t$.



The method of measurement of time t is described, as is also the calculation of the experimental error. The value found for the velocity $v = 36{,}000$ kilometres per second. A. E. G.

1889. *On the Active Agents in Luminescent Fluorspars and in Corundum and Spinel.* **T. Tanaka.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 501–510, April, 1924.)—This paper describes further researches in identifying the active agents of luminescent substances, continuing the work on calcites, aragonites, and dolomites [see Abstract 1887 (1924)]. The following substances are discussed: 17 samples of fluorspar, 2 of corundum, 1 of artificial ruby, and 1 of spinel. It is concluded that in most fluorspars the chief active agent is samarium, but other agents are yttrium, thallium, lanthanum, cerium, and probably ytterbium. The luminescent colours are violet, blue, and green, but these may change to orange when the substance is heated. Wiedemann and Schmidt established that the luminescent colour of alumina mixed with Fe_2O_3, CuO, or Mn_2O_3 undergoes essential variation when changes are introduced in the calcination temperature and in the concentration of the active metal, so that it appears unsafe in this case to consider the luminescent colour as a unique criterion by which to identify the chief active agent. From the data considered it is concluded that pure alumina is non-luminescent, but an infinitesimal amount of an impurity may produce a bright luminescence. Lecoq and Schmidt succeeded in obtaining pure alumina, but Crookes and Becquerel did not, and some, at least, of the red lines observed by Crookes and Lecoq are due to chromium, among them being the doublet at 6942 and 6937 Å.U. Many other lines found in Crookes' alumina spectrum must have been due to other sources not eliminated by the fractionation. The chief active agents of the luminescence of corundum are chromium and samarium, while iron and sometimes copper play a small part. Green luminescence in spinels is due to manganese. H. H. Ho.

1890. *Energy Distribution in the Glow Discharge.* **A. Günther-Schulze.** (Zeits. f. Physik, 23. 5. pp. 334–336, 1924.) From the Reichsanstalt.)—A supplement to previous work [see Abstract 604 (1924)]. A plane mercury kathode at room temperature is found to absorb, with varying currents and gas pressure, on the average about 80 per cent. of the kathode-fall energy in hydrogen, and about 85 per cent. in nitrogen and water-vapour. G. A. S.

1891. *The Disappearance of Gas in the Electric Discharge.* **Research Staff of the General Electric Co., London.** (Am. Electrochem. Soc., Trans. 44. pp. 87–98; Disc., 98–100, 1923.)—Experiments were carried out with evacuated incandescent tungsten lamps and results indicate that the disappearance or "clean up" of the residual gases by phosphorus is due to the adhesion of the gas to a film of solid deposited by the discharge on the walls of the container. Other substances behave similarly to phosphorus. The inactive gases are more difficult to eliminate than gases such as oxygen or CO_2, and a possible explanation to account for this difference is suggested. AUTHORS.

1892. *The Spark Lag.* **W. Hiller and E. Regener.** (Zeits. f. Physik, 23. 1–2. pp. 129–134, 1924.)—The conditions are investigated under which the dependence of the time of lag on the excess of the tension over the true discharge tension can be shown in a reproducible manner. Two curves are given in which the lag is plotted against the excess tension, the pressure in one case being 175·4 mm. Hg, and in the other 44·1 mm. Hg. It is further shown that in absolutely dry air the lag is only slightly reduced by ionising by radium or polonium preparations. It is proposed to continue the experiments, using other gases. A. E. G.

1893. *Effect of Shunts on Mercury Vapour Tube Current Wave Form.* **F. H. Newman.** (Phil. Mag. 47. pp. 939–940, May, 1924.)—A brief note accompanied by oscillographic records of the current through a mercury vapour tube when (1) unshunted; (2) shunted by an inductance; (3) shunted by a capacity; and (4) shunted by an inductance in series with a capacity. The discharge tube was a bulb about 12 cm. dia., with two pools of mercury as electrodes, having different surface areas. A voltage of 20,000 at a frequency of 60 was applied to the tube. In case (1) the current is a pure sine wave; in (2) peaked; in (3) very irregular in shape, exhibiting the superposition of higher frequency oscillations on the main wave during alternate half-cycles; while (4) exhibits a uni-directional condenser discharge. A. H.

1894. *The Relation between Current, Voltage and the Length of Carbon Arcs.* **A. E. R. Westman.** (Am. Electrochem. Soc., Trans. 43. pp. 171–186; Disc., 186–189, 1923.)—The conditions have been investigated for the formation of a steady arc between carbon electrodes with currents of 300 to 400 amps. and a fairly steady arc with currents up to 800 amps. The phenomena of humming, swinging, and groaning arcs are described. It is found that an arc can be easily maintained with a p.d. of 20 volts. Determinations of the distance between the electrodes for various currents and voltages are made by the use of a cathetometer and clay models. Changes in the voltage caused by raising or lowering the kathode for measured distances are determined. For currents between 300 and 400 amps. and a p.d. across the arc of 55 to 20 volts, the p.d. in volts is approximately equal to the distance between the electrodes in mm.; for currents of 700 amps. or so the voltage is less than the distance. The formulæ proposed by Mrs. Ayrton and by Steinmetz for low currents are not in agreement with the experimental results for high currents. J. N. P.

1895. *The Relation between Current, Voltage and the Length of Carbon Arcs. Part II.* **A. E. R. Westman** and **W. J. Clapson.** (Am. Electrochem. Soc., Trans. 44. pp. 137–150; Disc., 150–152, 1923.)—In an earlier investigation [see preceding Abstract] it was found that for currents of from 300 to 400 amps. the voltage over a carbon arc is approximately equal to the arc length in mm. when this is measured from the tip of the kathode to the bottom of the anode crater. In the present work more accurate measurements are made with a range of currents from 100 to 700 amps. and arc voltages from 15 to 60 volts. The arc is formed between graphite electrodes suitably mounted in an enclosure of fire-bricks, which is provided with an observation window. The anode is tapered at the end and the kathode recessed to form a crater. With currents of 400 amps. and above, the phenomenon of swinging becomes very persistent, observation showing two spots at opposite sides of the bottom of the anode crater, which appear dark and bright alternately at intervals of one-half second or less. This effect was avoided temporarily by drilling a hole 2 mm. in diameter in the centre of the anode. A description is given of the nature of electrode consumption and the general phenomena observed when employing a steady and different form of unsteady arcs. The distance between the electrodes during a run is determined by the use of a cathetometer, and measurements of the crater are made after a run by preparing a plaster model after the electrodes are allowed to cool in absence of air. The relation between the voltage (e) and the length of arc (L) in mm. is found to be independent of the current and to be expressed by the relation $e = 0\cdot 99\,L$. The results substantiate the conclusions of earlier work, and are in accordance with the results obtained by Watts. J. N. P.

1896. *Rotation of the Electric Arc.* **H. Stolt.** (Ann. d. Physik., 74. 1. pp. 80–104, April, 1924.)—Using a method similar to that of Nicol, the rotation of the electric arc under atmospheric pressure by a magnetic field is investigated, using electrodes of various materials. Magnetic field strength and length of arc are also varied. With constant current, i, but increasing magnetic field, and therefore increasing velocity of rotation, the potential difference, e, between the electrodes is found to increase. With decreasing i, e is found, for copper, silver and gold electrodes, to increase more rapidly than would be the case if Mrs. Ayrton's equation for the carbon arc held. Except for small currents, the velocity of rotation is found to be proportional to the current for all metals, lengths of arc and field strengths. The velocity seems to be determined by the material of the anode. In the case of copper it seems to be unaffected by the length of arc, but in the case of silver, for which the experiments were most accurate, an increase in length of arc results in a diminution of velocity. Assuming that the arc can be treated as a convection stream of positive and negative ions, Wilson and Martin deduced the relation $v = HXk_1k_2$, where v is the velocity of rotation, H the magnetic field strength, X the fall of potential in the arc, k_1 and k_2 the respective mobilities of the positive and the negative ions. Using this relation, and assuming that the positive ions are normally of the size of air molecules, and the negative ions are electrons, taking the arc temperature to be about 2000° C., a value for the velocity of rotation is calculated which agrees with that observed for various electrodes with a current of 1·5 amps. Further support is given to this relation by the fact that, on the basis of the assumptions that lead to it, almost all the changes in rotation velocity that are observed in practice can be explained. Such explanations are given in detail. An amplification of the research is contemplated. G. A. S.

1897. *Heat Losses and Chemical Action in the High Voltage, High-Frequency Discharge Through Air.* **F. Daniels, P. Keene,** and **P. D. V. Manning.** (Am. Electrochem. Soc., Trans. 44. pp. 245–255, 1923.)—A discharge was produced by a Tesla coil at about 100,000 volts in a large chamber constructed from a terra-cotta sewer pipe. A central wire 91·5 cm. (36 in.) long and a wire screen 41 cm. (16 in.) in diameter formed the electrodes. Outside the netting was a large cylinder of paraffined paper, and the whole chamber was arranged to function as a calorimeter. Of the electrical energy supplied to the primary of the transformer, 40 to 50 per cent. appeared as heat in the discharge chamber and 1 to 2 per cent. as chemical energy. The air was analysed for ozone and nitric acid. There is no advantage in discharges of this type for fixing nitrogen. The "cold" discharges waste just as much electrical energy in the form of heat as do the arcs, the only difference being that the consumption of electrical energy is small and so the temperature rise is less. **Authors.**

1898. *Chemical Action and the Disappearance of Gas in the Electrical Discharge Tube.* **F. H. Newman.** (Am. Electrochem. Soc., Trans. 44. pp. 77–84; Disc., 84–86, 1923.)—Nitrogen, at low pressures, is absorbed by most elements when an electric discharge is passed, particularly if the element is deposited in a thin film on the kathode. The elements which show this effect most markedly are phosphorus, sulphur, iodine, sodium, potassium, and the alloy of sodium and potassium. The rate of absorption is greatest with phosphorus and in all cases is greatest when the temperature of the discharge tube is maintained below 0° C. With sulphur, iodine and phosphorus no gas which has been absorbed is re-liberated on heating. By including a water voltameter in the secondary circuit, the amount of gas disappearing in the tube has been compared with the amount of hydrogen liberated in the voltameter, and it is found that generally more gas disappeared than hydrogen was liberated, which is held to prove that the absorption of the ions does not account for the large volume of gas which disappears. Hydrogen at pressures below 1 mm. is absorbed by most elements, but it is not possible to eliminate all traces of this gas by the electric discharge. Absorption of the gases is found to be due to the production of chemical compounds. The formation in this manner of the nitrides of sodium, potassium, magnesium and tin, and the hydrides of sodium, potassium and sulphur, is shown by chemical analysis. The combination can be brought about by gas after removal from the discharge tube, and the gas is considered to be in active condition, probably consisting of triatomic molecules. Although this active condition is caused by the ions, the results indicate that the number of active atoms or molecules in the gas is of a much higher order than the number of ions present in the gas at the moment of recombination. A similar absorption of gases is obtained at temperatures of about −40° C. after ionising by α-rays from polonium. A device for the continuous absorption of gases is described in which an arc is formed with a p.d. of 40 volts between two pools of sodium-potassium alloy placed in a quartz tube. J. N. P.

1899. *Oscillations in Coupled Circuits.* **E. T. Jones.** (Phil. Mag. 47. pp. 625–647, April, 1924.)—This paper deals with certain phenomena which occur when a high-tension transformer, an induction coil, or other coupled system in which the secondary circuit possesses considerable electrostatic capacity, is switched into a circuit in which oscillations of audible frequency are generated by a triode valve. The experimental arrangements and methods are described, a theoretical treatment is given, and typical oscillograms are reproduced. The original paper should be consulted.

A. W.

1900. *The Stable Amplitudes of Excited Coupled Oscillations.* **W. Runge.** (Archiv f. Elektrot. 13. pp. 34–48, March 31, 1924.)—A lengthy mathematical paper, not suitable for a brief abstract, on the hysteresis (*Ziehen*) effect in two retroactive oscillatory circuits. Previous theoretical results are considered, but these are limited by the impossibility of solution of the derived differential equations. The subject is then treated from a different point of mathematical attack in great detail and the results summarised, but these results are again purely mathematical and define the conditions for stability and hysteresis, the range of hysteresis, the relation of amplitudes in both circuits, and the relation of amplitudes and frequencies. B. J. L.

1901. *The Reflection and Refraction of Electrical Waves at a Stratified Medium.* **K. Försterling.** (Ann. d. Physik, 74. 2. pp. 171–176, May, 1924.)—This entirely mathematical paper deals with the reflection and refraction of electromagnetic waves in a medium composed of a series of plan parallel layers of different materials, which are assumed to be isotropic and optically inactive. H. H. Ho.

1902. *Resonance Curves with Different Types of Damping.* **D. Roschansky.** (Zeits. f. Hochfrequenztechnik, 23. pp. 23–31, Feb., 1924.)—A mathematical paper in which it is shown that by use of a practical method of approximation it is easy to follow numerically the resonance effects in a circuit, even for the case of so-called anomalous damping. The case of linear damping is specially discussed. The resonance equation deduced is adapted for calculating the true decrement, for which experimental methods also are given. The influence of the secondary damping on the anomalous resonance curves are discussed, and numerical illustrations are given. Different types of damping, which may occur with the spark discharge, are considered, and a new quantity, the mean damping factor, is introduced. This damping factor is obtained from the resonance curve, and can be employed for calculating the potential amplitude of the spark discharge. A. W.

1903. *Short-Wave Oscillations.* **G. Breit.** (Frank. Inst., J. 197. pp. 355–358, March, 1924.)—While trying to reproduce the oscillations described by Barkhausen and Kurz [Abstract 908 (1920)] with a triode tube of an experimental type a singular oscillation of an apparently new type has been observed. The arrangement of circuits is that used by Barkhausen and Kurz. The plate is disconnected, and the grid is connected to the positive pole of a 240-volt battery through a protective resistance of 500 to 2000 ohms. High-frequency oscillations of wave-length about 50 or 60 cm. are obtained if the filament current has the right value. Above or below this critical value of the filament current the oscillations stop. The range of variation of the filament current for which the oscillation occurs is not very regular, but is generally of the order of 0·05 amp. No explanation of the effects can as yet be given. Experiments with one tube containing a slight amount of gas show that the presence of gas to a slight degree is beneficial. A. W.

1904. *Short Electromagnetic Waves of Wave-length up to* 82 *Microns.* **A. Glagolewa-Arkadiewa.** (Nature, 113. p. 640, May 3, 1924.)—Up to the present short electromagnetic waves have been generated only by the method of the Hertz vibrator. This method offers very serious difficulties for the production of electromagnetic waves of the smallest possible length, as the vibrator burns out very soon, so that the amount of the energy and the length of the waves produced do not remain constant. Acting on a suggestion made by W. Arkadiew ten years ago, the present author has constructed a new type of wave generator substituting for the single Hertz vibrator a number of small vibrators and changing these frequently to avoid their burning out. Brief details with diagram are included. To detect the waves, thermo-elements of seven different types were used, and the measurement of the wave-lengths was carried out by the method of Boltzmann mirrors. The waves radiated by this new paste radiator lie between the short electromagnetic waves of Nichols and Tear on the one hand, and the Rubens heat waves on the other, and so fill the interval that has hitherto existed in the scale of the electromagnetic waves. These waves possess considerable energy, as shown by the possibility of using measuring instruments of ordinary sensibility, and are the results of independent electric oscillations in very small vibrators, not overtones of a vibrator or resonator, as has usually been the case in previous experiments. A transition is thus to hand from the radiation of an individual Hertz vibrator to the total radiation of an aggregation of molecules in a heated body. H. H. Ho.

1905. *Experiments on Short-Wave Lengths.* **R. Mesny.** (Onde Élec. 3. pp. 25–37, Jan., and pp. 99–110, Feb., 1924.)—An article in two instalments, the first of which deals with waves of the order of 1 metre in length, the second with waves of 40–50 metres in length. The very short waves are generated by a symmetrical arrangement of triodes [see Abstracts 374 and 717 (1924)]. The second instalment describes an attempt to investigate the theory of the Heaviside layer, making use of 45-metre waves for the purpose. The method was to compare, at different distances, the received signal strength of two stations transmitting with the same antenna current and the same wave-length; one of the aerials oscillating in a quarter wave-length in the usual manner, the other oscillating in a whole wave-length, and thus radiating its maximum energy in a direction at 35° to the horizontal. According to theory of a reflecting layer, the intensity due to the first station should decrease regularly with the distance, while that due to the second should be small at short distances, rise to a maximum, then diminish, and so on. The use of a 45-metre vertical antenna for the station oscillating in the whole wave-length necessitated a large steel mast, guys, etc. This was very unsatisfactory, making it almost impossible to maintain steady conditions. For the purposes of reception an attempt was made to interest amateurs, and it was hoped with their co-operation to obtain a sufficient number of observations to make an adequate test. Owing to difficulties with the transmission and the small number of reliable reports received the results were not conclusive. These experiments are to be repeated very shortly under improved conditions on a wave-length of 9 metres. A bibliography of the subject is given at the end of the article. F. S. B.

1906. *Wave Filters.* **F. Conrad.** (Teleg. u. Feruspr. Techn. 13. pp. 9–13, Feb., and pp. 17–19, March, 1924.)—A theoretical discussion following Wagner's treatment, and dealing particularly with the damping in various cases. Numerous diagrams are given. It is shown that the simple parallel arrangement of coils and condensers does not give the best results. Many interesting points regarding filter networks are brought out, but these cannot be enumerated without reference to the diagrams that are given. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1907. *The Resistivity and Temperature Coefficient of Iron Wire; the Effect of Impurities upon Them.* **S. Kimura** and **N. Namikawa.** (Electrot. Laborat. Tôkyô, Researches, No. 132. pp. 1–15, July, 1923. In English.)—The author has determined the chemical composition, electrical resistivity, and temperature coefficient of resistance, and the specific gravity of 35 specimens of telephone-telegraph wire. The samples were not subjected to any previous normalising heat treatment. Assuming that the resistivity, R, of a specimen of wire may be expressed in terms of the resistivity, K, of its iron content, and its percentage composition x, y, z, etc., of various impurities, by the relation $R = K + \alpha X + \beta Y + \gamma Z + \ldots$, X, Y, Z, etc., denoting the increase of resistivity per 1 per cent. of the respective impurities, the following values of these constants referring to iron and the respective impurities were determined: Iron, K = 9·66 microhms per cm. cube; and for silicon, 20·26; phosphorus, 10·69; manganese, 6·27; sulphur, 1·80; nickel, 1·46; copper, − 0·18; carbon, − 1·74 microhms per cm. cube. Values of the temperature coefficients of the respective wires at 20° C. range from 0·00391 to 0·00501 for de-zinced wires, and from 0·00383 to 0·00511 for the zinced wires. Values of the specific gravities of the wires at 20° C. ranged from 7·792 for de-zinced wire to 7·932 for de-zinced wire, and from 7·782 to 7·916 for zinced wire.

J. S. G. T.

1908. *Electrical Conductivities and Transition Points of Glasses.* **H. Schoenborn.** (Zeits. f. Physik, 22. 5. pp. 305–316, 1924.)—Experiments are described measuring the electric conductivities of different glasses at temperatures varying from 25° C. to about 600° C. For the glasses used the law of Hinrichsen and Rasch (*viz.*, $\log R = A/T + C$) is verified to well above the softening points. R is the electrical resistance, T the absolute temperature, and A and C are constants for a particular glass. At certain temperatures characteristic of the particular glass the values of A and C change suddenly. This points to molecular change in the glass. The electrical transition points coincide with the upper, and sometimes with the lower as well as the upper, limit of the "critical region," *i.e.* the region beginning with sudden increase of the rate of thermal expansion and terminated by the softening of the glass. These limits are found by means of an apparatus registering the thermal expansion photographically.

On lowering the temperature after having gone beyond the transition point some glasses show a relation between conductivity and temperature other than that which held for rising temperature. This is taken to be due to the formation of intermediate products in the process of cooling.

G. A. S.

1909. *Electrical Resistance and Thermoelectric Power of the Alkali Metals (−183° C. to 250° C.).* **C. C. Bidwell.** (Phys. Rev. 23. pp. 357–376, March, 1924.)—Pure samples of the metals were fused into glass or quartz tubes, and measurements were made by means of thermojunctions sealed into each end. Enough points were secured in each case to determine the slopes and the breaks in the curves. In both the resistance and thermoelectric power lines changes of slope are observed beginning gradually 100 degrees or more below the melting-point. These are taken to indicate transformations in each case from an α to a β form. These transformations occur at approximately the temperatures, 50° C. for Li, $-$ 20° C. to $+$ 20° C. for Na, $-$ 120° C. for K, $-$ 35° C. for Rb, and $-$ 80° C. for Cs. In all cases a sharp rise in thermoelectric power and resistance occurs as the melting-point is approached. The temperature coefficients of resistance decrease smoothly with increasing atomic weight for all forms.

The *atomic heat* of electricity as computed from thermoelectric data is approximately 0·24 cal. for Na and K, and 0·58 cal. for Rb and Cs. The values are too small to account for the observed excess of the atomic heats for these metals above the equipartition value. AUTHOR.

1910. *Dependence of the Thermoelectric Force of Iron on its Structure.* **W. Heraeus.** (Ann. d. Physik, 73. 7–8. pp. 554–576, March, 1924.)—It is shown that the experimental methods employed by Borelius and Gunneson [see Abstract 1904 (1922)] in their research on the thermo-curve of non-glowing pure iron as compared with glowing pure iron must lead to false results. A new method for determining the thermo-force of glowing pure iron as compared with non-glowing pure iron is given, and by the use of this method the following results are obtained. The thermo-curve is investigated for the temperatures 60° to 900°. The curve is not reproducible at lower temperatures. The shorter the duration of the glowing, the sharper are the breaks in the thermo-curve between 60° and 900°. The wires employed are examined microscopically, and it is found that recrystallisation begins at approximately 500° and progresses up to 900°. A. E. G.

1911. *Preparation of Platinum and Platinum-Rhodium Alloy for Thermocouples.* **R. P. Neville.** (Am. Electrochem. Soc., Trans. 43. pp. 371–382; Disc., 382–384, 1923.)—In the course of a number of experiments it is found that, by fusing a specially prepared sponge of the metal under treatment in crucibles of pure thoria or lime by means of an Ajax-Northrupp high-frequency induction furnace, Pt and Pt-Rh alloy are obtained yielding thermocouples which only drop off on 25 hours' heating at about 1600° C., the equivalent of about 1° C. In the *discussion* the technical details given in the paper are compared by various workers with their own experiences. A. B. C. L.

1912. *Experimental Studies on the Nature of the Internal Electrical Charge of the Electret.* **M. Eguchi.** (Phys. Math. Soc. Japan, Proc. 5. pp. 107–113, Sept., 1923. In English.)—The author describes experiments with small condensers, to decide whether the dielectric is polarised in Maxwell's sense, or the phenomena are due to ions held fixed within the material; a mixture of equal parts of carnaüba wax and resin was used for the dielectric, and the voltage was switched on while the dielectric was still in the liquid state. With a simple disc electret well-balanced polarities were observed on the two surfaces, the applied pole of one of which was earthed. On the day following the preparation, temporary surface charges were observed, $-4{\cdot}2$ and $+2{\cdot}8$; after a few days the sign of these charges was reversed, and after about a month there were nearly settled free charges of the electrification, with well-balanced polarities $+5{\cdot}0$ and $-4{\cdot}9$, $+4{\cdot}9$ and $-5{\cdot}1$, $+4{\cdot}4$ and $-4{\cdot}9$ being observed at different dates during more than five months. Similar results were obtained when the dielectric was divided into two layers by a metal plate, between and parallel to the two electrodes; and also with a paper separator. Division into slabs by sawing gave irregular results at first; but after some months permanent polarisation was observed. The author concludes that the electrification of the electret is of the nature of polarisation, in Maxwell's sense of the term. H. N. A.

1913. *Light Sensitivity of Cuprous Oxide and of Selenium.* **V. P. Barton.** (Phys. Rev. 23. pp. 337–344, March, 1924.)—Light from a tungsten lamp or iron arc was dispersed by a quartz spectrometer. Measurements with a thermocouple enabled all results to be reduced to unit light intensity. The observations agree well with previous results obtained with various samples. (1) Decrease of resistance was measured for the range 3900 Å. to 6000 Å. for Cu_2O (maximum at 4600 Å.), and for 4300 Å. to 9300 Å. for Se (maximum at 7000 Å.). (2) Photoelectrolytic potential was found to exist for both back (contact with air) and front (contact with distilled water) illumination, and was measured in the case of front illumination for the range 2700 Å. to 5500 Å. for Cu_2O (maximum at 3500 Å., upper limit about 5600 Å.), and for 2700 Å. to 9000 Å. for Se (maximum at 5700 Å., upper limit about 9500 Å.). The effect was positive and proportional to the intensity I for Cu_2O and to $I^{\frac{1}{2}}$ for Se. (3) Photoelectric wave-length limit was found by the use of absorption screens to be at about 2570 Å. for Cu_2O and at 2260 Å. for Se. For both Cu_2O and Se all samples showed the same photo-electric limits, and those which showed a change of resistance also showed the photoelectrolytic effect, but not *vice versa.* AUTHOR.

1914. *The Dielectric Constants of Hydrogen, Oxygen, Nitrogen, Air and CO_2 by a High-Frequency Method.* **E. C. Fritts.** (Phys. Rev. 23. pp. 345–356, March, 1924.)—Special cylindrical gas-condensers were constructed so as to have a minimum of solid dielectric in the field, and the small capacities were measured by the method of heterodyne beats, originally used by Hyslop and Carman. A photographic record of the beats on a moving film was secured, one side of the wedge slit being fastened to a tuning-fork and the other to the diaphragm of a telephone actuated by the beats. The results reduced to 1 atm. at 0° C., accurate to about 1 per cent. of the difference from vacuum, are: hydrogen 1·000263, oxygen 1·000507, nitrogen 1·000555, air 1·000540, and CO_2 1·000948. The values for N_2 were found to be independent of the frequency between 1230 and 600 metres, and to be proportional to the pressure from 44 to 69 cm. The values for air, N_2 and O_2, differ by 8 per cent. from those of Boltzmann and of Rohmann. AUTHOR.

1915. *Amplification of the Currents of Photoelectric Cells.* **G. Ferrié, R. Jouaust and R. Mesny.** (Comptes Rendus, 178. pp. 1117–1120, March 31, 1924.)—The specially selected triode lamp previously used [Abstract 654 (1924)] is replaced by a two-grid lamp of everyday manufacture, and an arrangement is described by which the plate voltage can be adjusted in such a way as to give a much greater amplification than that obtainable with the triode lamp. An application to stellar photometry is given. It is further indicated how still higher sensitivity is obtainable by using in series with the photoelectric cell a condenser whose discharge after a ten-seconds' illumination of the cell produces a sudden variation of the plate current twelve times as great as the steady change produced in the absence of the condenser. The study of this last method is being continued.

G. A. S.

1916. *New Type of A.C. Potentiometer.* **W. Geyger.** (Archiv f. Elektrot. 13. pp. 80–82, March 31, 1924.)—Referring to D. C. Gall's instrument [see Abstract 1663 (1923)], the author describes a form of A.C. potentiometer which he has for some time past used with satisfactory results. The general arrangement is shown in Fig. 1, where M_1, M_2 are two potentiometer wires carrying equal currents of the same frequency and in quadrature phase relation. The middle points A_1 and A_2 of the wires are connected together. K_1 and K_2 are the sliding contacts provided with index threads whose intersection may be read off on the polar diagram attached to the base-board, the magnitude as well as phase of the unknown e.m.f. being thereby read directly. Although a number of methods are available for obtaining the necessary quadrature phase relation between the currents, the arrangement preferred by the author is that shown in Fig. 2, which is self-explanatory.

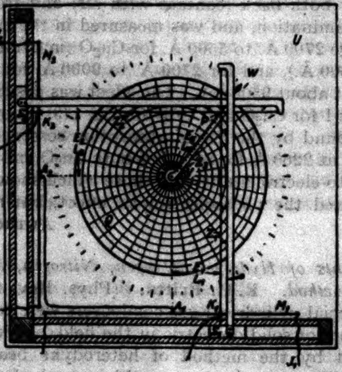


FIG. 1.

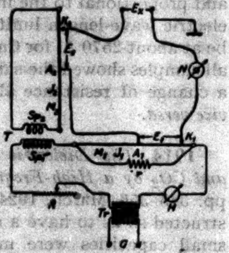


FIG. 2.

A. H.

1917. *A New Photoelectric Cell.* **J. Tykocinski-Tykocyner** and **J. Kunz.** (Science, 59. pp. 320–321, April 4, 1924.)—Two bulbs are joined by a transparent glass tube and each is provided with a hemispherical deposit of potassium and with a platinum electrode. The usual photoelectric effect exhibited by such a cell when the electrode connected to the negative pole of a battery is illuminated is considerably increased if the tube connecting the bulbs is also illuminated. Thus when the battery voltage is 20 volts the photoelectric current increases about twenty-five times when the tube is illuminated, whilst at 120 volts the increase is 50 %, and at 200 volts is 4 % only. The increase of current is linearly related to the value of the illuminated area of the tube, and the effect is selective, depending both on the wave-length and intensity of the radiation illuminating the tube. A similar effect is produced if thermions are employed in place of photo-electrons projected from the kathode. In either case the inner surface of the tube acts like a transparent grid controlling the flow of electrons from a radiating source. J. S. G. T.

1918. *Measurement of Low Resistance by Means of the Wheatstone Bridge.* **F. Wenner** and **Alva Smith.** (Bureau of Standards, Sci. Papers, No. 481. pp. 297–305, 1924.)—Resistances which are small can be definite only if they have distinct current and potential terminals. In the arrangement described, the current terminals serve for connecting the resistance into the bridge circuit, while the potential terminals serve as branch points. This puts the connecting resistances into arms adjacent to the arm containing the unknown resistance, their effect therefore being made smaller than with the usual arrangement in the ratio of the unknown resistance to the resistance of the adjacent arms. In cases where the errors still caused by the connecting resistances need be considered, two supplementary measurements with the same apparatus may be made practically to eliminate them. With a recently calibrated bridge a resistance of the order of 0·001 ohm is measured to an accuracy of 0·6 % directly, and 0·03 % after applying the correction obtained by the supplementary measurement. A. B. C. L.

1919. *Rotary Interrupters and the J.L.P. Interrupter.* **J. Levêque-Petit.** (Assoc. Ing. El. Liège, Bull. 2. Ser. 7. pp. 98–104, March, 1924.) —The desirable characteristics of a rotary interrupter are: (1) The interruption of the current should be abrupt, (2) the area of surfaces in contact when the circuit is closed should not be less than 5 sq. mm. per amp., and (3) an arc must not be struck after rupture of the contact. Deficiencies in respect of these requirements have been found in a large number of rotary interrupters, and a description is given of an interrupter designed by the author to satisfy these requirements. J. S. G. T.

1920. *The Work of the Laboratoire Central d'Électricité since its Foundation.* **P. Janet.** (Soc. Franç. Élect., Bull. 4. pp. 93–126, Jan., 1924.)

1921. *An Electrometer with Triode Valve and its Application to the Measurement of the Electrical Gradient of the Atmosphere.* **P. Lejay.** (Comptes Rendus, 178. pp. 1480–1482, April 28, 1924.)—The current in the triode valve is within wide limits a linear function of the potential difference between the grid and the filament. Variations of potential due to a source placed in the grid circuit will therefore be easily deduced from the records of a milliammeter connected in the plate circuit, when the heating of the filament and the plate potential are maintained constant and the grid current is not modified by the difference of potential to be measured. The author has now employed such a valve on the lines recently published by Ferrié, Jouaust, and Mesny [Abstract 1915 (1924)]. The source charges a condenser whose positive is connected permanently to the filament. When equilibrium is established the negative is abruptly connected to the grid. The consequent discharge then produces a current diminution easy to measure which is a function of the quantity of electricity stored by the condenser and therefore of the potential difference established by the source before the discharge. The milliammeter functions ballistically and affords a discontinuous record. Its deflections have been experimentally shown to be proportional to the potentials measured. The apparatus was standardised by replacing the source with batteries giving known potential differences. The method was then applied to the measurement of the electrical gradient of the atmosphere, the apparatus being capable of easy transport. H. H. Ho.

1922. *Some Uses of the Thread Recorder in the Measurement of Physical Properties.* **J. L. Haughton and W. T. Griffiths.** (Journ. Sci. Instruments, 1. pp. 225–233, May, 1924.)—Applications of the thread recorder manufactured by the Cambridge and Paul Instrument Co. to (1) recording the elongation of a wire heated to various temperatures in an electric furnace, (2) recording the value of the electrical resistance of a conductor through a range of temperature, and (3) converting two records obtained, *e.g.* time-temperature and time-property records, into a temperature-property record. In the case of (3), the thread-recorder drum containing the two records is driven slowly below two pointers which can be moved by lead-screws in a direction parallel to the axis of the drum. The pointers both indicate the same time on the record. By rotating the lead-screws by hand whilst the drum is rotated by a motor, the pointers are caused to follow the respective curves. One of the lead-screws drives a table the displacement of which is therefore proportional to the ordinates of one curve. The other lead-screw, through a pair of 45° bevel wheels, drives a pencil at right angles to the displacement of the table and through a distance proportional to the respective ordinates of the other curve.
J. S. G. T.

1923. *A Direct Method to Determine the Sense of Rotation of Braun Tube Diagrams.* **K. Seiyama.** (Inst. El. Eng. of Japan, J. No. 425. pp. 950–957, Dec., 1923.)—A stroboscopic method was adopted for this purpose, a thin metallic disc having small holes on a concentric circle being maintained in rotation. By looking at the fluorescent screen through the holes of the revolving disc, the fluorescent spot is seen to move in the same sense as, or opposite to, the direction of rotation of the diagram, according to the frequency of the diagram, the speed of the disc, and the number of holes. If the number of holes be made equal to the number of pairs of poles of the induction motor, the spot always seems to rotate in the same direction as the diagram. W. R. C.

1924. *Method for Determining Total Intensity of the Earth's Field from a Moving Support.* **H. R. Grummann.** (Terrest. Magn. 29. pp. 41–46, March, 1924.)—An apparatus is suggested which might be used on board ship without requiring to be stabilised, as the effect of the motion on its indications is eliminated automatically. It consists of three earth inductors with axes at right angles, each rotating at constant angular velocity. These velocities are kept in a constant ratio, *e.g.* 3 : 5 : 7, by means of suitable gears, and the frequency of rotation must be high compared with the frequency of roll of the vessel. The three alternating e.m.f.s are led to the grid of a valve which operates as a rectifier; it is shown that the average value of the change of the plate current, from its value when the coils are at rest, is proportional to the square of the total force, and is measured by a d.c. galvanometer. G. E. A.

ALTERNATING CURRENTS AND MAGNETISM.

1925. *Peak Voltage Measurement by Means of a Neon Glow-Lamp.* **L. E. Ryall.** (World Power, 1, pp. 288–291, May, 1924.)—It is well known that the neon glow-lamp requires a certain "striking voltage" before any current passes and a glow appears. This fact can be easily utilised in the measurement of peak voltages. In one method a potentiometer resistance is joined across the a.c. supply in parallel with a voltmeter. A second voltmeter in parallel with the neon lamp is connected across the sliding contacts of the potentiometer, the position of these being adjusted until the lamp "strikes." If V_1, V_2 be the readings of the two voltmeters, V_g the striking voltage of the lamp, the peak voltage of the a.c. supply is V_gV_1/V_2. For high frequencies or for high voltages a condenser potential divider, consisting of a fixed and a variable condenser in series, is preferred; the lamp is put across the variable condenser which is adjusted until the glow appears. The condenser can be calibrated to read the peak voltage directly. Tests were made using the "Beehive" pattern Osglim lamps, these giving the smallest variation of striking voltage when tested under the same conditions. The apparatus was compared with a calibrated kathode-ray tube, and it was found that the striking voltage was constant over a wide range of frequency within 1 % of the mean value. The results agree with those found by Palm for tubes with cup and disc electrodes filled with neon at 5–12 mm. of mercury pressure. It was further found by tests with a telephone in series with the lamp that the appearance of the glow is a sufficiently precise method of determining when the current starts to flow in the lamp. The paper concludes with details of a neon-lamp voltmeter of the calibrated variable condenser type described above, suitable for a range of 3000–30,000 volts at normal frequencies. The necessary modifications for use at radio-frequencies are indicated. B. H.

1926. *Determination of the Wave-Form of Alternating Currents by Means of the Braun Tube.* **L. Casper, K. Hubmann, and J. Zenneck.** (Zeits. f. Hochfrequenztechnik, 23. pp. 32–34, Feb., 1924.)—The method here dealt with is that in which two deflection coils (placed horizontally on either side of the tube) are connected in series with an iron-free inductance (L) in the alternating current circuit, the two ends of the inductance being connected to the two deflection plates of the Braun tube, arranged vertically one above the other. A curve is thus obtained on the screen of the tube whose vertical ordinates are proportional to the alternating current (I), and whose abscissæ are more and more nearly proportional to dI/dt the smaller the ohmic resistance of the coil L with respect to its inductance. Numerous curves are given showing the effect of the presence of harmonics, particularly the second and third, of different amplitudes. [See Abstract 803B (1916).] A. W.

1927. *The Skin Effect in Tubes.* **K. Försterling.** (Ann. d. Physik, 74. 2. pp. 176–185, May, 1924.)—This paper applies the author's optical methods for high-frequency problems to the skin effect for a metallic tube whose interior is filled with a dielectric, and is a continuation of previous work on the behaviour of an iron wire coated with copper. The treatment is entirely mathematical. H. H. Ho.

1928. *The Skin Effect in Tubes.* **M. Wien.** (Ann. d. Physik, 74. 2. pp. 186–188, May, 1924.)—A comparison is here given between Försterling's results [see preceding Abstract] for the skin effect in tubes in the limiting case of slow oscillations, and those obtained by means of the older mathematical methods [see Abstract 2272 (1904)]. Exact agreement is found, and the author trusts that the methods will find further application.

H. H. Ho.

1929. *Registration of Electromagnetic Oscillations of High Frequency.* **A. Dufour.** (Comptes Rendus, 178. pp. 1478–1480, April 28, 1924.)—The author has previously described [see Abstract 964 (1923)] a kathode-ray oscillograph for the study of low, medium, and high frequencies. In the present paper the results are indicated which this oscillograph is able to give from the point of view of registering graphically oscillations still more rapid, which may be properly called Hertzian oscillations, since their frequencies range from 100 millions to 1 milliard per second.

A. E. G.

1930. *The Control Field in Magnetic Hysteresis.* **R. C. Gray.** (Roy. Soc. Edinburgh, Proc. 44. 1. pp. 84–87, 1923–1924.)—According to Ewing the atom of a magnetic substance consists of two parts, (1) the Weber element, of constant moment, and capable of turning in an applied field, (2) a group of fixed magnets (electrons moving in orbits) which have like poles directed to the centre of the atom [Abstract 1722 (1922)]. The directions of the fields due to the fixed groups are positions of stability for the Weber element. In the demagnetised state each Weber element occupies a position of stability. For a small applied field the Weber element rotates reversibly, and the angle turned through depends on the control field due to the fixed magnets. The author shows theoretically that the initial susceptibility is equal to the saturation intensity divided by twice the control field. From magnetisation curves the control field for soft iron is calculated as 20, and for modern magnet steel 500. The saturation coercive force varies with the control field, but is probably independent of the moment of the Weber element. It is about one-fourth of the magnitude of the control field. The maximum angle of reversible deflection for a specimen of hardened cast iron is calculated as 4°·8. This is double that from the relation $I = I_s \sin \theta$, where I is the intensity of magnetisation at the field at which residual magnetism appears. The theory conforms with the fact that the initial susceptibility is greater after heat treatment of the specimen than after subsequent demagnetisation by reversals.

L. L.

1931. *Magnetic Isothermals of Nickel.* **P. Weiss** and **R. Forrer.** (Comptes Rendus, 178. pp. 1046–1049, March 24, 1924.)—A large number of curves is given, in which the specific magnetisation or moment per unit mass is plotted with the field for each of a number of temperatures from 20° to 405° C. The Curie point (357°) does not appear in the curves; it was determined by means of the magneto-caloric effect. Spontaneous magnetisation disappears at 360°, and at 405° the specific magnetisation is proportional to the field intensity. The magnetisation is specified as either apparent or true, the latter being defined by the condition that it is at all points parallel to the field. In the curves given, these two kinds are drawn; the isotherms of true magnetisation are derived from those for apparent magnetisation by a method to be described.

G. E. A.

1932. *Influence of Carbon and Carbides on the Magnetic Properties of Steel.* **A. W. Smith, E. D. Campbell** and **W. L. Fink.** (Phys. Rev. 23. pp. 377–385, March, 1924.)—The effect of changes in carbide concentration on the magnetic properties of heat-treated carbon steels, studied by Campbell and Johnson by means of a gravity magnetic balance [Abstract 378 (1923)], was further investigated, using a magnetic potentiometer in conjunction with a bar and yoke apparatus. The steels consisted of two series of short bars with carbon varying from 0·01 to 1·17 per cent., one of Armco iron, and the other of chrome magnet steels of given composition. The carbon content was obtained and controlled by maintaining the bars at 950° C. in hydrogen along with steel of different carbide content until equilibrium was attained. In the bar and yoke apparatus, the winding of the magnetising coil was designed to produce the same total flux in bar and yoke. The magnetic potentiometer consisted of a solenoid of several thousand turns with soft-iron end plates to make contact with two points of the test bar. Adjustment was made by setting the current round the bar and then varying the current round the yoke until, after many reversals of both currents, there is no change of flux through the coil of the potentiometer. The galvanometer connections were then shifted to a test coil round the bar to measure the flux through the bar. Magnetisation curves are given for the different bars. It is found that the minimum reluctivity R is a linear function of the carbon content up to 0·8 per cent. C. for hardened steels. For annealed carbon steels R increases somewhat faster than the per cent. C; for annealed chrome steels R shows a maximum at about 0·5 per cent., and a minimum at about 0·8 per cent. C. The field intensity for saturation varies in the same way as the reluctivity. G. E. A.

1933. *Characteristics of Iron in High-frequency Rotating Magnetic Fields.* **L. Tonks.** (Phys. Rev. 23. pp. 221–238, Feb., 1924.)—An investigation of the behaviour of discs of electrolytic iron in fields of 0·7 to 5 gauss rotating 52,000 to 172,000 times per second. Treating the disc as a very oblate spheroid, the problem is investigated mathematically, and equations are derived from which H and I can be computed from measurements of the impressed field, the fluxes through a coil with and without the disc in it, and the torque exerted on the disc by the rotating field. The field was produced by two double Helmholtz coils with axes at right angles, each in series with a separate oscillating circuit coupled to a main oscillating circuit actuated by three valves in parallel. The disc was 0·001 cm. thick, and was suspended horizontally at the middle of the Helmholtz coils. The results agree with previous work [See Abstracts Nos. 731 (1910), 1732 (1913) and 1132 (1915)], and show that the susceptibility decreases as the frequency increases; the hysteresis angle tends to increase with frequency; the hysteresis loss per cycle, E_h, increases with frequency for constant magnetic intensity and decreases for constant field. As the frequency varied from 52 to 172 kilocycles, the exponent a in $E_h = AH^a$ increased from 2·9 to 3·37. G. E. A.

1934. *Thermomagnetic Phenomenon and the Specific Heat of Nickel.* **P. Weiss** and **R. Forrer.** (Comptes Rendus, 178. pp. 1347–1351, April 14, 1924.)—The thermomagnetic phenomenon dealt with in this note is the reversible thermal effect which accompanies magnetisation. By analogy with the Clapeyron equation this effect may be written $C_H . \Delta T = \frac{\partial \sigma}{\partial T} . \Delta H$. C_H is the specific heat at constant field, ΔT the change of temperature for change of field, ΔH and σ the specific magnetisation. Series of curves are given in the paper showing values of ΔT for different values of H and at various temperatures in the case of Ni.

From 20° to 277°·5 the elevation of temperature is proportional to the field. This indicates that the external field is small compared with the internal field. From 277°·5 to 357° (Curie point) the curves are concave to the axis of field-strengths. $\partial\sigma/\partial T$ thus diminishes with increase of H. The curves do not pass through the origin. The phenomenon is determined wholly by the internal field. For all fields the temperature change is most marked in the neighbourhood of the Curie point. For a field of 17·775 c.g.s. units it is 1°·25 at this temperature, but only 0°·03 at ordinary temperature in the same field.

The value of C_H is calculated by means of the equation (Clapeyron), using the observed thermomagnetic data. Its variation with temperature is similar to that obtained by calorimetric measurements. It increases continuously up to the Curie point, then diminishes abruptly, and finally approaches a constant value. L. L.

1935. *Thermomagnetic Phenomenon. Real and Apparent Magnetisation.* **P. Weiss** and **R. Forrer.** (Comptes Rendus, 178. pp. 1448–1452, April 28, 1924.)—The change of temperature observed in the thermomagnetic phenomena described in a previous paper [see preceding Abstract] can be written according to the molecular theory $\Delta T = A(\sigma^2 - \sigma_0^2)$, where A is a constant. Below the Curie point a substance possesses, in the absence of external field, magnetisation σ_0. At first, the external field is directive, and there is an observable apparent magnetisation, but no temperature effect. Later there is a true increase accompanied by the thermal phenomenon. Above the Curie point σ_0 is zero and $\Delta T = A\sigma^2$. The change is not abrupt, there is a transition stage between the two types in the neighbourhood of the Curie point. Curves are given in the paper co-ordinating ΔT and σ^2 for various temperatures above and below the Curie point. These experimental data conform with the theory. L. L.

1936. *Magnetic Susceptibility of Oxygen, Hydrogen and Helium.* **A. P. Wills** and **L. G. Hector.** (Phys. Rev. 23. pp. 209–220, Feb., 1924.)—The manometric method was used, and a manometric balance is described in which the effect of the field on the gas is opposed to its effect on a standard solution of nickel chloride. Exact balance is attained by varying the pressure of the gas or the common temperature. The theory of the method is given and working formulæ are derived for paramagnetic and diamagnetic gases. The volume susceptibility k_0 is found for a pressure of one atmosphere at 20° C. For oxygen, k_0 is $0{\cdot}1447 \times 10^{-6}$, and it is verified that the susceptibility varies inversely as the square of the absolute temperature, in accordance with Langevin's theory for a paramagnetic gas. For hydrogen, k_0 is $-1{\cdot}64 \times 10^{-10}$, and for helium $-0{\cdot}807 \times 10^{-10}$. Tänzler's value for helium, viz., $-17{\cdot}5 \times 10^{-10}$ [see Abstract 478 (1908)] is considered too high, a conclusion which is supported by applying W. Pauli's theory for a diamagnetic monatomic gas [see Abstract 728 (1921)]. G. E. A.

1937. *Annual Report of the Director of the Department of Terrestrial Magnetism.* (Carnegie Inst. of Washington, Year Book No. 22. pp. 229–266, 1923.)

1938. *Characterisation of Terrestrial Magnetism and Variability of Natural Phenomena.* **S. Ono.** (Terrest. Magn. 29. pp. 33–40, March, 1924.)—A method is developed for characterising terrestrial magnetism, the theories proved being applicable to determine the variation of any natural phenomenon. The method is based on the building up of a curve from that formed by joining its consecutive maxima and minima by straight lines. The quantity $\partial y/\partial x$ is called the variability of y with respect to x, and to some extent corresponds to Bidlingmaier's "activity" [see Abstract 1239 (1911)]. $\overline{V}$ is defined as the resultant variability; it is the statistical mean of $\int_0^l (\partial y/\partial x)dx \div l$, and is expressible in various ways, the simplest of which is $\overline{V} = 2\xi_0^2$, where ξ_0 is the mean change in y between a maximum and a minimum. Numerical examples are taken from magnetograms recorded at de Bilt observatory between 21st and 25th March, 1913, and the calculated resultant variability, expressed in $(\gamma/\text{hour})^2$ units, is found to agree well with the true value. G. E. A.

1939. *A Portable Magnetometer.* **J. H. Shaxby.** (Journ. Sci. Instruments, 1. pp. 234–237, May, 1924.)—A portable magnetometer of the commutated inductor type, arranged to measure the vertical intensity and the dip of the earth's magnetic field, is described. The inductor consists of a simple hand-driven coil, the axis of rotation of which is set in the magnetic meridian, and the vertical intensity of the earth's field is determined by neutralising the effect of this component by that due to a horizontal coil supplied with an adjustable current from a small secondary cell. The dip is then determined by tilting the instrument through an angle θ about an axis transverse to the axis of rotation of the coil, such that the galvanometer remains undeflected for the same value of the current in the horizontal coil as previously. The dip is then equal to $90° - \theta/2$. J. S. G. T.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1940. *Studies in Adsorption. Part VI. Adsorption and the Schulze-Hardy Law.* **N. R. Dhar, K. C. Sen and S. Ghosh.** (J. Phys. Chem. 28. pp. 457–474, May, 1924.)—The Schulze-Hardy law, which establishes a relation between the coagulating power and the valency of the coagulating ion is only partially fulfilled in the case of the coagulation of manganese dioxide sol. It has also been definitely proved experimentally that in the adsorption of various electrolytes by precipitated manganese dioxide the ions most effective in coagulation are least adsorbed. A survey of the experimental results on coagulation show that an ion which has a high precipitation value (a small coagulating power) for a colloid is most adsorbed by the colloid. Inversely the smaller the precipitation value (that is, the greater the coagulating power), the less is the adsorption. This is the proper explanation of the Schulze-Hardy law.

When an electrolyte is added to a sol, the first step is the neutralisation of the electric charge on the colloid particles by the adsorption of ions carrying a charge opposite to that of the sol. The second step is the further adsorption of the electrolyte by the neutral particles. It is only for the first step that the Schulze-Hardy law is applicable. The existence of a minimum concentration of electrolytes for coagulation of colloids is explained by a suggestion based on kinetic and adsorption points of view.

Reversal of charge depends upon amount as well as on the permanency of adsorption. Hydrogen, hydroxyl, etc., ions, which are more or less permanently adsorbed in large quantities, are most active in charge reversal. Substances which are neither strongly basic or acidic are capable of adsorbing positive or negative ions, and pass into the colloidal state. Charge reversal is possible in those colloids where the neutraliser particle of the sol can immediately adsorb more of the precipitating ion. The opinion is expressed that charge reversal, amount of adsorption, and complex formation depend on chemical affinity existing between the adsorbent and the substance adsorbed. Experimental work recently carried out proves that soil acidity is very likely due to the adsorption of basic portion from salts by silica, humic acid, etc., present in the soil.

F. J. B.

1941. *Relation between Hydrogen Content of Certain Charcoals and Some Other Properties.* **H. H. Lowry.** (Am. Chem. Soc., J. 46. pp. 824–846, April, 1924.)—Experimental details are given of the determination of chemical composition and measurements of apparent density in air and different liquids, sorptive capacity, and porosity of 23 samples of non-activated charcoal prepared from anthracite coal. It is indicated that the H content (0·21 – 0·53 % of chemically combined H) varies with the maximum temperature at which the samples are heated, and that complete elimination of H only occurs at graphitisation temperatures. Apparent densities in different liquids are practically independent of the immersion fluid, the data supporting neither the penetrability hypothesis of Cude and Hulett nor the compressibility hypothesis of Harkins and Ewing. Pore volumes are found to decrease with decreasing H content, indicating a shrinkage of the charcoals at higher temperatures. The observed relationship between the apparent density in water and the H content of the charcoals is taken as confirmation of the modified penetration hypothesis. That sorptive capacity increases with increasing H content is shown to be in accordance with the view, consistent with all known available evidence, that so-called amorphous carbons are hydrocarbons of low H content built up of polymarised residues from the thermal decomposition of hydrocarbons of greater hydrogen content, and that any treatment tending to increase the unsaturation of these residues will increase the sorptive capacity of the charcoal. A. B. C. L.

1942. *Adsorption of Vapours by Charcoal.* **A. S. Coolidge.** (Am. Chem. Soc., J. 46. pp. 596-627, March, 1924.)—The conditions capable of yielding reliable results in the measurement of adsorption of vapours by charcoal are discussed. The charcoal must be freed from gas at a definite maximum temperature, the system annealed at a moderately raised temperature after admission of the vapour, and the readings taken during the pumping-out of the vapour.

Of the nine vapours examined over a temperature range from 0° to 300°, and at pressures varying from 0·0002 mm. to 1000 mm., benzene is the most completely stable in contact with charcoal, even at the highest temperature reached. The adsorption in this case may, indeed, serve as a type, the logarithmic isotherms varying gradually and continuously in slope from low temperatures and high concentrations, where the pressure p is approximately proportional to the twentieth power of q, the amount adsorbed per gram of charcoal, to high temperatures and low concentrations, where p becomes directly proportional to q. Somewhat similar results are obtained with other compounds, but with water and methyl alcohol the logarithmic isotherms are concave instead of convex upwards, and never indicate equality of p and q.

Additional evidence is obtained that the adsorbed material exists as a liquid, even below the freezing-point of the free liquid. T. H. P.

1943. *Adsorptive Capacity of Wood Charcoal for Dissolved Substances in Relation to the Temperature of Carbonisation.* **J. C. Philip** and **J. Jarman.** (J. Phys. Chem. 28. pp. 346-350, April, 1924.)—Analyses have been made of a number of charcoals prepared by carbonising birch-wood for certain periods at definite temperatures. From the results of measurements of the adsorptive power of these charcoals in relation to iodine, oxalic acid, methylene-blue, tartar emetic and quinine sulphate, it appears that the optimum temperature for the production of an active charcoal by carbonisation alone varies with the nature of the substance to be adsorbed. At the higher temperatures employed, increased facility for access of air during the carbonisation results in marked rise in the activity. T. H. P.

1944. *Absence of Helium from the Gases left after the Passage of Electrical Discharges. I. Between Fine Wires in a Vacuum. II. Through Hydrogen. III. Through Mercury Vapours.* **S. K. Allison** and **W. D. Harkins.** (Am. Chem. Soc., J. 46. pp. 814-824, April, 1924.)—A powerful condenser of approximately 0·5 microfarad capacity, charged to 42,000 volts, is allowed to discharge through very fine points consisting of platinum or tungsten wires 0·0025 cm. in diameter, enclosed in an evacuated bulb.

The condenser is divided and reconnected in series so that it can be charged to 84,000 volts. The discharge is then allowed to pass through saturated mercury vapour at 90° C., 0·1 mm. pressure, between accurately round steel balls 3·2 cm. in diameter. The gases evolved in these discharges were tested for helium; 168 discharges were made between points with 42,000 volts p.d., as above described, and the discharge was allowed to pass through the mercury vapour 300 times. Hydrogen was liberated in all the trials, but in no case was helium detected, even by the use of the highly sensitive spectroscopic method of Soddy, which will detect 2×10^{-10} g. of helium. It is found that ordinary spectroscopic methods for the detection of helium are, on the other hand, not at all sensitive. In no case is the amount of heat produced noticeably greater than that to be expected from the condenser discharge alone. The theory of atomic disintegration is discussed, and it is pointed out that the failure of the electrical discharge methods to disintegrate the atom is due to the fact that energy is not transmitted to the nucleus in a sufficiently high concentration. Electrons with velocities of several million volts may prove effective, though thus far only high-speed α-particles have induced disintegration, as in the experiments of Rutherford. The condenser, using the 84,000-volt arrangement, is discharged 100 times through a 500 c.c. bulb containing very pure hydrogen at 40 mm. pressure. This is repeated three times. Tests by the method of Soddy reveal no trace of helium. A. E. G.

1945. *The Electronic Theory of Valency.* **B. Flürscheim.** (Phil. Mag. 47. pp. 569–576, March, 1924.)—Replies to a paper by T. M. Lowry, Abstract 338 (1924). The electronic theories of Fry, Vorländer, Lapworth and Robinson, Eastman, Huggins, Crocker, and finally Lowry are considered, and it is stated that a list of 110 facts, to be published soon, shows that the assumptions made in these theories do not agree with the experimental evidence; Lapworth and Robinson have, however, promised further developments as to the interpretation of their theory, which postulates conjugated addition for *o*- and *p*-, and ± alternation for *m*-; the author has postulated varying alternation through varying affinity demand of the substituting atom (Lapworth's "key atom"), and molecular addition at maximum free affinities, with no assumptions as to the ultimate nature of chemical affinity. The physical assumptions underlying the electronic bond theories appear to offer considerable logical difficulties, some of which are mentioned; with positive-negative alternation "electrons must be shifted sinultaneously, and in the same molecule, in the same and in opposed directions!" It is suggested that many authors show a preference for the number 8, to gratify which they will set aside the fundamental law of electrostatics. According to the author chemical reactions are, in the general case, governed by three internal factors: the *amount* of affinity available at the reacting atom (quantitative factor), which depends on the distribution of the affinity force in the molecule; the *kind* of affinity available at the reacting atom (polar factor = general polarity); the magnitude of steric hindrance affecting the reacting atom (steric factor). It is shown how these different factors have to be taken into account in the case of a number of organic compounds such as benzene derivatives, those of propionic acid, and of other acids. H. N. A.

1946. *The Valency Bond, Electrovalence and Covalence.* **S. H. C. Briggs.** (Phil. Mag. 47. pp. 702–713, April, 1924.)—When atoms combine by electrovalence a transfer of one or more electrons takes place from the positive to the negative element, the resulting ions being held together by general electrostatic attraction. With combination by convalence no electrons are transferred, two or more electrons being shared between the combining atoms. A diagrammatic illustration of the molecule of a strong electrolyte is studied, and it is argued that the difference between electrovalence and covalence is only a difference of degree, the electrons being shared equally in covalence compounds and unequally in electrovalence compounds, the more unequal the sharing the greater the polarity of the compound. On similar lines of investigation the combination of a number of molecules to form a simple cubic space-lattice is studied. The special features presented by aluminium chloride, sulphuryl fluoride, boron triethyl, and other compounds are considered in relation to valency combination, the general conclusion being drawn that the separation of compounds into two sharply-defined classes—electrovalence compounds with varying degrees of polarity and non-polar covalence compounds—cannot be supported. A. B. C. L.

1947. *Adsorption of Binary Mixtures by Animal Charcoal, and Comparative Study of the Adsorptive Power of Different Varieties of Charcoal.* **N. A. Yajnik** and **T. C. Rana.** (J. Phys. Chem. 28. pp. 267–278, March, 1924.)—Adsorption of a substance by charcoal is found to be increased, although only slightly, by rise of temperature. With increased dilution of a dissolved substance, the relative amount adsorbed increases, but the absolute amount diminishes. As regards binary mixtures, it is found that either (1) the presence of a foreign substance may have no effect on the adsorption of another substance, the adsorption thus depending very little on the ionisation, or (2) a substance may be adsorbed to a less extent in presence of another substance than if pure, or (3) adsorption of a substance may be increased by the presence of, or at the expense of, another substance. Thus, no general rules are followed and the effect of a substance on the adsorption of another cannot be predicted. Adsorption by wood charcoal which has been previously heated approximates to or even exceeds that by animal charcoal. With some exceptions the order of adsorption of compounds is the same for different charcoals. T. H. P.

1948. *Atomic Species and their Abundance on the Earth.* **F. W. Aston.** (Nature, 113. pp. 393–395, March 15, 1924.)—The relative abundance in the earth of the different types of atoms, including the known isotopes, is shown in a diagram, in which $\log_{10}$ abundance, in gramme atoms, is plotted against mass numbers, for the first 39 elements; the number of gramme atoms is a multiple of the number of atoms, so that it can be estimated that the total number of O^{16} atoms in the lithosphere, hydrosphere, and atmosphere is nearly 10^{50}, with about one-third that number of Si^{28} atoms. The diagram shows the proponderance of elements of even atomic number by a series of peaks; and the importance of atomic weights, or mass numbers, of the type $8n$ is shown. There is a very marked contrast between the range of abundance of the isotopes of any one element and that of the elements themselves; there are about 3 Cl^{35} atoms to 1 Cl^{37} and about 2 Ga^{69} atoms to 1 Ga^{71}, yet there are a thousand million times more atoms of Cl than of Ga. It seems improbable that such differences are altogether due to the difficulty of detecting isotopes, the relative amount of which in an element is small, and there appear to be only two possible ways of accounting for them; either the available sample of matter is entirely unrepresentative, or the similarity between isotopic atoms must be even deeper than has been supposed. The fact that the relative abundance of the elements in meteorites is much the same as that on the earth is against the first idea, so that the close abundance relations between the isotopes of any element must be connected with the structure of the nucleus and its stability in evolution; all atoms of the same element may contain an "inner nucleus" in common, the stability of the inner nucleus determining the abundance of the element; outer parts may be added to this in different ways, forming isotopes, without altering the stability greatly. The following facts support this idea: the mass relation between the isotopes of tin is integral to the highest accuracy; the same is true of those of xenon; but the masses of the tin and xenon isotopes are not related integrally, those of tin being lighter; this is to be expected if the "inner nucleus" of tin is lighter than that of xenon. H. N. A.

1949. *The Electro-chemistry of Gases.* **S. C. Lind.** (Am. Electrochem. Soc., Trans. 44. pp. 63–71; Disc., 71–75, 1923.)—Measurements are made of the amount of chemical change accompanying known amounts of ionisation produced by radio-active agencies. A comparison in different cases of the number of reacting molecules with the number of pairs of charges indicates that the gas ions are chemically active and constitute the intermediate activated products of reaction. In the decomposition of CO into CO_2 and C, it is found that 2 molecules of CO are decomposed for each molecule of CO which is ionised, and that the free electrons take no part in the chemical action through formation of negative ions, but merely act to re-establish the electrical neutrality. The following general conclusions are drawn: (1) Free electrons promote chemical reaction of gases only when a gas is present capable of forming a negative ion by attaching the free electrons. (2) Gas ions tend to form charged complexes by attaching themselves to electrically neutral molecules. These complexes are the intermediate compounds of chemical reaction. (3) Activated molecules or atoms do not interact among themselves, but react with unactivated molecules. For instance, O atoms at a low concentration will combine with CO to give CO_2, but will not react with each other to form O_2. CO_2 is not decomposed by α-particles, but in presence of H_2, which acts as an acceptor, reaction occurs with the probable intermediate formation of the complex $(H_2CO_2H_2)^+$ similar to $(H_2O_2H_2)^+$, which is probably given in water formation. (4) A low momentary concentration of activated substance is capable of explaining the action of negative catalysis or inhibitors. (5) Active ions may be destroyed by reverse action either in a uni- or multi-component system, without any effective chemical action resulting. This reversal may be prevented by a suitable acceptor. (6) In the absence of at least one gas with affinity for electrons a lower ratio of chemical change to ionisation is obtained than when one is present. A secondary *rôle* is always played by electrons in restoring final electrical neutrality. J. N. P.

1950. *Solubility Curves for the Decomposition of Double Salts.* **S. M. Levi.** (Zeits. phys. Chem. 108. pp. 411–430, March, 1924.)—It is pointed out that the decomposition of double salts in solution is indicated from the solubility relations to a greater extent than has been generally realised.

At the transition points there can exist in contact with the saturated solution three solid phases, the double salt AB and both of its components A and B. In the case of complexes which are only stable at higher temperatures, the transition point corresponds to the lowest temperature at which the double salt can exist. Below this point only a mixture of the components is stable. A somewhat higher point known as the beginning of the transition interval represents the lowest temperature at which the double salt can be dissolved in water without decomposition. The occurrence of a transition interval is determined by there being a difference in the solubilities of the two components of a double salt.

Graphs are drawn in the case of some typical double salts, in which the ratio of the components in saturated solutions is represented by the ordinates and the temperature by the abscissæ. Each solid phase present in the system has a characteristic solubility curve. The transition point is given by the intersection of the solubility curve of A in a solution of A + AB with that of the solubility curve of A in a solution of B + AB. This coincidence occurs at the same temperature as the intersection of the solubility curve of B in A + AB with B in B + AB. The beginning or maximum temperature of the transition interval occurs at the point of intersection of the solubility curve of A in a solution of B + AB with that of B in B + AB. Data on the limits of the transition interval are given in the case of a series of analagous double salts of the type $ZnNa_2(SO_4)_2$, $4H_2O$. A discussion is given of the results of similar measurements by Koppel. A detailed investigation is made of the solubility of $NaNH_4SO_4$, $2H_2O$, which is only stable at lower temperatures and decomposes at temperatures above its transition point of 59° C. A discussion is given of the rule of Meyerhoff, which relates the transition point to the solubility curve of the disappearing phase. This rule is considered to be untenable. J. N. P.

1951. *The Law of Solubility of Salts.* **P. Mondain-Monval.** (Comptes Rendus, 178. pp. 1164–1166, March 31, 1924.)—The expression $d \log L/dC = -d \log i/dT$ is derived for the solubility of salts, where i is given by $dF/F = i dC/C$. The value of i is determined experimentally by measurement of the vapour pressure of ammonium nitrate solutions at various concentrations and temperatures. The result obtained gives $\Delta i/\Delta T = 0{\cdot}0059$. By calculation from the formula and the values for the solubility and heat of solution determined previously by the author (Comptes Rendus, 177. p. 175, 1923.) the result is $\Delta i/\Delta T = 0{\cdot}00535$. This agreement is quite satisfactory if the difficulty of measuring vapour pressures is taken into consideration. B. W. C.

1952. *The Natural Water Corrosion of Steel in Contact with Copper.* **W. G. Whitman** and **R. P. Russell.** (Indust. and Engin. Chem. 16. pp. 276–279, March, 1924.)—Experiments are described in which the natural water corrosion of steel in contact with a metal lower in the electromotive series has been quantitatively determined. The results show that the total corrosion is the same with bare steel plates as with steel specimens of the same size having 75 % of their surface copper plated, that is, in the latter case the corrosion per unit area of steel is four times as great as in the former. The total corrosion observed is determined by the total effective surface available for the depolarisation of hydrogen by dissolved oxygen, the actual corrosion occurring on the steel alone. The experiments were made by exposing 5·1 × 15·2 cm. surface of mild steel plates to water flowing under a constant head. The copper-plated plates were slightly polished with emery paper so as to remove the copper coating over a small definite area. The rates of corrosion were calculated as follows: the consumption of 1 c.c. of the dissolved oxygen of the water is equivalent to 3·32 mg. of iron as Fe_2O_3. The specific corrosion rate is defined as milligrammes of iron corroded per sq. cm. per year per cubic centimetre of oxygen per litre.

K = c.c. of O_2 consumed per year × 3·32/area of iron surface in sq. cm
× average concentration of O_2,
= 4,020,000 × litres water per minute × log (initial O_2/final O_2) area
of iron in sq. cm.

It was found that after a short initial period of high corrosion the rate becomes constant. The data are in accord with an electrolytic mechanism of corrosion. The rate of corrosion is limited by the rate at which oxygen can diffuse in to react with the surface film of nascent hydrogen. F. J. B.

1953. *Dilution Law for Uni-Univalent Salts.* **B. Szyszkowski.** (J. Phys. Chem. 28. pp. 193–211, March, 1924.)—The author shows that, by rejecting the classical conception of partial dissociation of strong electrolytes into ions and by admitting Ghosh's hypothesis of complete dissociation of salts into ions independently of the concentration of their solutions, a theory of electrolytic dissociation compatible with experimental data can be established. The theory is worked out by a thermodynamic method, which implies no assumption concerning the mechanism of electrolytic dissociation. T. H. P.

1954. *Electrolytic Dissociation of Some Salts in Furfural.* **F. H. Getman.** (J. Phys. Chem. 28. pp. 212–220, March, 1924.)—For lithium, sodium, potassium, rubidium, ammonium, and tetra-ethylammonium iodide in furfural solutions, the values of the conductivity ratio, $\Lambda : \Lambda_0$, are relatively high, so that this solvent must be regarded as possessed of high dissociating power. The curves connecting conductivities with the cube roots of the concentrations show that the values of the conductivity of solutions of ammonium iodide and tetra-ethylammonium iodide increase more rapidly with dilution than do the corresponding values for the other iodides; this may be due either to an abnormality in the dissociation of the alkali iodides in furfural, or to the tendency of the ammonium radicle to react with the aldehydic solvent.

None of the furfural solutions studied conform to Walden's relation involving the viscosity and dielectric constant of the solvent, $K = \eta_0 . D(v)^{0.45} . d_v = 51 \cdot 4$. The degree of solvation of the kations of the different salts has been calculated and found to be approximately of the same order of magnitude as in aqueous solutions. The Storch equation is found to express the functional relationship between conductivity and concentration of the solutions of the different salts with considerable accuracy, the value of the exponent, n, in the equation $C(\Lambda - \Lambda_0) = KC\Lambda^n$, being greater than for the corresponding aqueous solutions.
T. H. P.

1955. *Distribution of Colloidal Particles.* **E. F. Burton** and **J. E. Currie.** (Phil. Mag. 47. pp. 721–724, April, 1924.)—Perrin's conclusion that, for regions very near to the surface of a colloidal solution, the law of distribution of the particles is analogous to that regulating the distribution of molecules of gas in the atmosphere [Perrin, "Atoms," 1916], was based on experiments for distances up to only 0·1 mm., yet the impression is held that it is valid for all distances [Abstract 392 (1923)]. Further experiments on the lines of those previously described [Abstract 1787 (1922)] have been made with gamboge, arsenious sulphide, copper, and silver, special care being taken to protect the solutions from change of temperature and from light. The results leave little room for doubt that the particles in these solutions are distributed uniformly and that such distribution is regulated by some mutual action of the particles, this being most probably due to the possession of like electrical charges.

T. H. P.

1956. *Volumes in the Vicinity of the Critical State of Miscibility.* **N. Perrakis.** (Comptes Rendus, 178. pp. 1482–1483, April 28, 1924.)—The author has shown [see Abstract 1516 (1924)] that the influence of the vicinity of the critical state of miscibility on the volumes is denoted by a deformation of the curve giving, as a function of the composition, the variations of volume produced in mixtures of two components of a binary system. Also, that this curve presents an appreciable rectilinear part indicating the proximity of the region of non-miscibility. The present paper records a continuation of this work, the curve deformations being systematically studied at 20° for the volumetric variations exhibited by mixtures of benzene with the first four primary alcohols. The four curves are included, and show: (1) Rectilinear portions indicating states of non-miscibility, the degrees of miscibility increasing from the benzene-methyl alcohol system to that of benzene-normal butyl alcohol; (2) that the volume variations increase upwards in the alcohol series, and it is suggested that for an alcohol sufficiently high in the series a pseudo-parabolic curve would be given. H. H. Ho.

1957. *The Osmotic Equation of State and the Activity of Dilute Strong Electrolytes.* **P. Debye.** (Phys. Zeits. 25. pp. 97–107, March 1, 1924.)—The osmotic and activity relations of strong electrolytes formerly published [Abstract 2541 (1923)] are now derived in a new manner involving some simplification. The law of osmotic pressure and the osmotic equation of state are taken as the starting-point on the assumption that this law is accurately known for the limiting case of disappearing molecular forces and defined by the known relation for the thermodynamic potential or free energy of dilute solutions. The deductions are compared with the conclusions on the activity of strong electrolytes which have been derived experimentally by G. N. Lewis. Departures from the ideal or van't Hoff relations are the more marked the greater the degree of dissociation and the higher the valency of the ions. The purely Coulomb molecular forces, as being the main determinants, are alone considered in this paper. The additive terms required by the osmotic law are derived mathematically by thus considering only factors which operate at high dilutions and neglecting effects, such as the size of the ions and other factors, which apply at high concentrations. A consideration is made of the energy change involved in bringing a solution from a low to a high concentration isothermally on account of the mutual electrostatic forces exerted by the charge on the particles. By considering the energy change involved in removing from, or restoring an electric charge to, the ion in an atmosphere of given ionic concentration and dielectric constant, the following relation is derived: Representing the van't Hoff expression for the ideal osmotic pressure by $P' = \Sigma n_i kT$, the actual osmotic pressure is given by

$$P = \Sigma(1 - \epsilon_i^2 X/6DkT)n_i kT,$$

where ϵ_i is the charge on the individual particle, X the density of the ionic atmosphere, D the dielectric constant, k the Boltzmann constant, T the absolute temperature, and n_i the number of ions of the type i. The term X is defined by the expression $X^2 = 4\pi\Sigma n_i \epsilon_i^2/DkT$. The thermodynamic potential in the case of high dilutions is given by the expression

$$Z = \Sigma N_i(\zeta i + kT \log c_i - \epsilon_i^2 X/3D).$$

Formulæ to evaluate the influence of concentration on this potential are derived mathematically.

The activity coefficient as employed by Lewis is determined by the expression $\log f_i = \epsilon_i^2 X/2DkT = -\epsilon^2/2DkT\sqrt{(8\pi\epsilon^2/DkT)\,.\,(N/1000)J}$. The ionic strength, J, of the solution is determined by the expression $J = \frac{1}{2}\Sigma z_i^2 \gamma_i$, where γ_i is the number of molecules per litre corresponding to ions of the type i and the valency z_i. From this expression numerical values are calculated for the activity coefficients of typical electrolytes and the results compared with those obtained by Lewis. In accordance with the conclusions of Lewis, it is seen that the determining factors in the energy relations of a solution are the density of the ionic atmosphere which at low concentrations is proportional to the square root of the ionic concentration, and, with the exception of their valency, is independent of the individual properties of the ions. It is shown that at sufficiently high dilution, the osmotic equation of state passes into the form $Pv_0/kT = \nu C - \log f_0$, where $-f_0$ represents the departure from the osmotic law due to molecular forces and ν the number of ions into which a molecule breaks down. Further, $\log f = -3\alpha C^{1/2}$, where α is a constant and C the concentration. J. N. P.

1958. *Changes by the Extension of Zinc Crystals.* **E. N. da C. Andrade.** Comments on a paper by H. Mark, M. Polányi, and E. Schmid. (Zeits. f. Physik, 22. 5. pp. 343–344, 1924.)—[Abstract 991 (1923).] F. J. B.

1959. *X-Ray Examination of Metal Films.* **W. H. Bragg.** (Nature, 113. p. 639, May 3, 1924.)—In the Bakerian Lecture of 1857 Faraday discussed "The experimental relations of gold and other metals to light." His investigation had been after the mode in which finely-divided gold affected the colour of incident light, in particular the transparency acquired by gold-leaf heated to a little below the softening temperature of glass. Later, Beilby ascribes the transparency to an opening up of the molecular structure, thus modifying a suggestion of Faraday's that it was due to an opening up of grosser portions of the metal. The transparent leaf, when pressed by the smooth round end of an agate pencil, becomes once more green by transmitted and yellow by reflected light. This effect is of considerable interest not only on its optical side, but also because it is a simple case of change due to cold working and subsequent annealing, and such changes produced in metals by rolling and drawing have been examined by X-ray methods by Mark, Schmid, Weissenberg and Polanyi [see Abstract 2531 (1923)]. The present examination has been undertaken on some of Beilby's pure gold films, using a Müller spectrometer, which is well adapted for the purpose. The film was mounted on glass, and in most of the experiments the sheet was used as a reflecting-face, being equally inclined to the incident and reflected rays. Brief experimental details with three photographs are included. From the results obtained it appears that the beating puts some strain into the crystal, though it increases the amount of arrangement. Heating relieves the strain, *i.e.* allows surface tension to come into play. The greater strain is also the probable cause of the greater response to chemical action which is found in the beaten state. H. H. Ho.

1960. *Maximum Temperatures Attainable in Combustion of Fuels.* **G. A. Goodenough** and **G. T. Felbeck.** (Univ. of Illinois Eng. Exp. Sta. Bull. No. 139 [160 pp.], March, 1924.)—The work available from reactions at high temperatures is not generally the exact equivalent of the heat of reaction; in addition, the reaction cannot proceed to completion, but halts when the constituents attain a state of chemical equilibrium. The maximum temperature is thus definitely limited. This explains the discrepancy between the indicated pressures of explosion in an engine cylinder and those calculated by methods involving three usual but unjustifiable assumptions: (1) that the combustion process is adiabatic; (2) that the specific heat of the products is constant, whereas this increases with the temperature; and (3) that combustion is complete, which is untenable by the law of chemical equilibrium, according to which the mixture at the point of maximum pressure must contain a considerable amount of uncombined CO and H_2. In this paper a *résumé* of the important laws of gaseous mixtures is given, together with a general theory of chemical equilibrium. The determination of conditions of chemical equilibrium is a fundamental problem in the investigation of temperatures and pressures due to combustion. The equilibrium equation for various reactions is derived by the method of thermodynamic potentials. The analyses of exhaust gases of a petrol engine as given by Watson, including methane and formaldehyde, can thus be satisfactorily explained. The energy equation is developed and the method of solving the system of equations for the calculation of maximum temperature is shown. The data from explosion experiments by David and by Bone and Haward are examined and the observed and calculated temperatures compared. The effects are studied, for various fuel gases, of varying the initial pressure and temperature of the gas mixture and of excess air and loss of heat during combustion. Tizard and Pye's approximate method of calculating maximum explosion temperatures for liquid fuels is discussed and their values re-calculated by the more exact procedure, the results being in close agreement. The question of water injection is noticed. Numerical examples are given for petrol-air and kerosene-air mixtures and also for the flame temperatures attainable in oxy-hydrogen and oxy-acetylene welding. Available data on specific heat and heat of combustion of various gases are collated in two appendices. J. V. H.

1961. *Gaseous Explosions at High Pressures. Part IV. Influence of Initial Pressure upon the Rate of Pressure-Development and the Activation* *of Nitrogen in CO-Air Explosions.* **W. A. Bone, D. M. Newitt and D. T. A. Townend.** (Roy. Soc., Proc. 105. pp. 406–433, April 1, 1924.)—The experiments [Abstract 2013 (1923)] have been continued with initial pressures P_i ranging from 3 to 100 atmos. Whilst in mixtures of H, N, O, or of CO, O, an increase in P_i shortens the time t_m required to develop the maximum pressure P_m, the reverse holds for CO-air and $(2CO + O_2 + 4N_2)$ mixtures. As long as P_i does not exceed 3 atmos., t_m, P_m and the rate of cooling are the same for $(2CO + 2O_2 + 4N_2)$ as for $(2CO + O_2 + 4O_2)$, the N acting merely as diluent. At $P_i = 10$, the energy-absorbing function of N becomes apparent. At first (P_i from 10 to 25 atmos.) there is also a large exothermic effect during the cooling period, without appreciable lowering of the corrected P_m value. That remains so even at 50 atmos., if experimental conditions are rendered unfavourable to the formation of NO by a partial replacement of N by its equivalent of CO. The corrected P_m is slightly affected at $P_i = 25$ atmos. and more at higher P_i by the secondary NO-formation in a normal CO-air mixture. This formation is favourably affected by an excess of oxygen. On the other hand, nitrogen exerts no such energy-absorbing function in hydrogen-air mixtures, even at the highest rate P_i of 75 atmos.; there is in this case hardly any NO-formation, though the t_m is little lower, 2820° against 3020° K. Speaking generally, no after burning or exothermic effect could be detected in mixtures such as $(2H_2 + O_2 + 4N_2)$, $(2CO + O_2)$ or $(2CO + O_2 + 4Ar)$ at P_i above 10 atmos., and there was no sign of a limitation of t_m in $(2CO + O_2)$ mixtures, even when the temperature went up to 5200° K. These facts are best explained by a primary N_2-activation owing to an absorption of the peculiar radiation emitted by burning CO-molecules, which may or may not be followed by a secondary NO-formation depending upon favourable experimental conditions. A primary NO-formation of a purely thermal character would not explain all the facts. A resonance reaction between CO and N_2 in these explosions would accord with the modern view as to the similarity of the electronic constitutions of the CO- and the N_2-molecules. This radiation arises from direct interaction between CO and : O atoms (or possibly O_2-molecules) rather than from interaction between CO and OH_2-molecules, because the partial replacement of CO by H_2 in the CO-air explosions counteracts the N_2-activation as was previously shown by the authors. The point is further studied by a spectroscopic investigation of the effect of gradual additions of hydrogen to CO-flames. That the percentage of the formation of NO in explosions of coal gas and of CO-air was greater than could be accounted for by a purely thermal effect had been observed by F. Hausser; he suggests an effect of ultra-violet radiations ("Chemistry and Industry," p. 750, August 3, 1923), but the authors do not accept this view. H. B.

1962. *Spectrophotometric Determination of Hydrogen-Ion Concentrations and of the Apparent Dissociation Constants of Indicators. Part I. Methods.* **W. C. Holmes.** (Am. Chem. Soc., J. 46. pp. 627–631, March, 1924.)—For an indicator coloured in only one of its forms the suitable ratio R_1 for defining the degree of transition at any point within the zone of colour change is that of the intensity of the absorption at such point to that of an equal quantity of indicator under conditions ensuring maximum intensity. With indicators which exhibit the essential behaviour of monobasic acids or bases, and with which complete transformation may be obtained, the numerical value of R_1 represents the percentage colour transformation. With two-colour indicators two ratios of this type may be employed, or use may be made of the ratio R_2 of the intensities of absorption at two wave-lengths selected at or near the respective maxima of the two absorption bands in question. The results obtained with two indicators give in each case regular variations between the values of *p*H and R_2. Thus spectrophotometric ratios of either or both the above general types may be used for the evaluation of hydrogen-ion concentrations, it being necessary merely to determine the ratios with suitable indicators in buffered solutions affording small intervals in *p*H values over their effective ranges. T. H. P.

1963. *An Electrometric Method of Following Certain Inorganic Hydrolytic Reactions.* **G. S. Tilley** and **O. C. Ralston.** (Am. Electrochem. Soc., Trans. 44. pp. 31–41; Disc., 41–42, 1923.)—The use of the air electrode has been investigated for the purpose of following hydrolytic reactions, such as the removal of ferric iron and aluminium from copper sulphate solutions by various basic substances like powdered limestone, copper oxide, etc. Changes in direction of the voltage-time curve, or of the voltage-hydrolysing agent curve, allow of following the process without the need of chemical analysis. The method likewise applies in the purification of zinc sulphate solutions and of aluminium sulphate solutions, and can be extended to other similar problems. AUTHORS.

1964. *Arrangement for the Delivery of Measured Small Volumes of Liquid.* **E. Müller.** (Zeits. Elektrochem. 30. pp. 187–188, April, 1924.)—A burette for use in electro-titration experiments is described which is fitted with an arrangement to allow definite small measured volumes of liquid to be run off, in order to facilitate manipulation near the end point of the determination. B. W. C.

1965. *Reactions of the Lead Storage Battery.* **M. Knobel.** (Am. Electrochem. Soc., Trans. 43. pp. 99–104; Disc., 104–106, 1923.)—This investigation was carried out with a view to determining whether the reactions suggested by Féry or those of the usual double sulphate theory are correct. The former involve one mol of sulphuric acid per two faradays on discharge, whereas the latter involves two mols. Experiment shows that the amount of acid varied with the rate of discharge, but at low rates two mols were required. It thus appears that Féry's theory is not supported. W. R. C.

1966. *Direct Measurement of Polarisation Capacity and Phase Angle.* **C. W. Miller.** (Phys. Rev. 22. pp. 622–628, Dec., 1923.)—Using symmetrical condensers in which the separation of the plates could be varied from 0·002 cm. to 0·3 cm., the series resistance and the capacity for small current density were measured by means of an alternating-current bridge. Within the errors of the experiment, the "initial" capacity was independent of the separation of the plates, and the resistance was a linear function of the separation, approaching, however, a definite surface resistance as the distance between the plates was reduced. For concentrations greater than hundredth normal it was possible to work with such small separations that the resistance of the electrolyte could be neglected in comparison with the surface resistance. Direct measurements were, therefore, possible of capacity, resistance, and phase angle (tan^{-1} ωCR). Using potassium bromide as electrolyte and clean gold electrodes as soon as possible after immersion in the electrolyte, a study was made of the variation of these constants with concentration, and for a few frequencies from 570 to 3500 cycles. The capacity varied very nearly directly and the resistance inversely as the one-fourth power of the concentration, the product CR being nearly constant. The phase-angle was very nearly constant for variations both of concentration and of frequency, showing only a slight decrease with increasing concentration and a slight increase with increasing frequency. It was about 65°. AUTHOR.

1967. *The Life Period of Overvoltage Compounds.* **E. Newbery.** (Chem. Soc., J. 125. pp. 511–518, March, 1924.)—The overvoltage is measured by making observations at various commutator speeds and extrapolating to infinite speed. The overvoltage hydrides of zinc and chromium appear to be stable; graphite, silver and platinum less stable; cadmium, copper, nickel and lead are unstable or variable in composition on the electrode surface. The methods adopted by Glasstone, and also by Tartar and Keyes, are criticised, and their theories shown to be untenable. It is pointed out that alternating current ammeters cannot be used for measuring intermittent direct current in overvoltage determinations. B. W. C.

1968. *Effect of Current-Density on Overvoltage.* **M. Knobel, P. Caplan,** and **M. Eiseman.** (Am. Electrochem. Soc., Trans. 43. pp. 55–74; Disc., 75–78, 1923.)—Attention is drawn to the large effect on overvoltage that may be expected when the current-density is high as compared with values for low current-densities. Also there is the important question of eliminating resistance drop when taking measurements. The reference electrode is sometimes placed behind the kathode in an attempt to eliminate the potential drop, but this method is deprecated. If the reference electrode tip is placed on the front side of the electrode it disturbs the current flow lines. A large tip, or one pressed too closely to the surface, would cause an appreciable decrease in current-density in the electrolyte immediately between the tip and the electrode and the value for overvoltage would be too low. Curves are given showing the effect of varying size of the electrode tip and the effect of varying the distance from the electrode surface. From these experiments the authors came to the conclusion that it was best to use a tip of approximately one millimetre in diameter and to press it lightly against the active electrode during measurements. A small piece of cotton is inserted in the end of the tip to prevent bubbles entering the tube and breaking the electrical circuit.

The effect of varying the current-density was determined by setting the current at the desired value and making the electrode potential determination within one minute of this setting. The values so obtained were found to be more reproducible than by allowing the experiment to run on for five or ten minutes, during which time the electrode would change considerably. The general form of the current-density overvoltage curves so obtained is more or less logarithmic. Metals generally specified as having a high overvoltage rise sharply to a high overvoltage at low current-densities and then increase but little with increasing current. Metals of low overvoltage show a more gradual increase. No hydrogen overvoltage thus measured exceeds the value of about 1·30 volts, but the trend of most of the curves is towards this value. Platinised platinum maintains its low overvoltage even at exceeding high current-densities.

W. R. C.

1969. *Variations in the Cataphoretic Mobilities of Oil Drops in Water.* **M. Mooney.** (Phys. Rev. 23. pp. 396–411, March, 1924.)—The Helmholtz theory of electric endosmose is first described, following which comes a reference to the formulæ of Lamb and Smoluchowski for the cataphoretic velocity of a suspended particle. The latter's formula gives velocity as independent of size of particle, and the present experimental investigation deals with this problem for very dilute emulsions of oil in water. The cell used was a thin-walled glass tube 20 cm. in length and 6 mm. diam., with gold electrodes sealed into the ends, held in a vertical position. By means of a microscope, velocity measurements were made on suspended drops both along the axis and in the stationary layer $R/\sqrt{2}$ from the axis, where R is the inner radius. For emulsions of ten oils in distilled water, the mobility for a field of 10 volts/cm. was found to increase with the diameter D for the range from 0·0005 to 0·04 mm. This is also true for emulsions of stanolind in weak electrolytes, but for 0·0008*n* $CuSO_4$ the mobility is constant. In all cases the drops were negatively charged. Variation with the potential gradient is not exhibited by the smaller drops, but large ones, above 0·02 mm., show a slight increase for fields of 10 volts/cm. Observation on a large drop in a capillary tube open at both ends and immersed in a dish filled with 0·0001*n* NaOH, indicates that the mobility increases with time during the first five or ten sec. after the electric field is applied. As explanation, it is suggested that the electric double layer around a drop is considerably distorted by an external electric field, so that equilibrium is established rather slowly. For the endosmotic flow of water in a closed cylindrical tube, hydrodynamic theory gives the velocity as a linear function of the square of the distance from the axis, with a zero value for $r = R/\sqrt{2}$. This has been experimentally verified. The mobility past an oil surface was measured after coating the inside surface of the cell with oil, and was found approximately equal to the cataphoretic mobility of large drops of oil in water. This is also true for 0·0004 molar $CuSO_4$ solution.

H. H. Ho.

1970. *Electro-Osmotic Experiments on the Reversal of the Electrical Charge of Colloids and Precipitates and the Preparation of Stable Sols with a Charge Opposite in Sign to that Commonly Obtained.* **J. N. Mukherjee** and **B. C. Roy.** (Chem. Soc., J. 125. pp. 476–488, March, 1924.)—The authors discuss the reversal of the charge of colloids from the point of view of the origin and neutralisation of the electrical charge. The adsorption of an oppositely charged ion is due mainly to electrical forces and two types of adsorption by colloids may be distinguished: (1) Primary adsorption of ions owing to the chemical affinity of the surface atoms; the charge on the surface of colloids (hydrophobe) in water as dispersion medium is due to this type. (2) Electrical adsorption of oppositely charged ions, this being a secondary effect due to the surface being charged as a consequence of the primary adsorption of ions. It follows from these views that reversal of the charge of the surface by electrical adsorption is possible only when the valency of the oppositely charged ion is greater than that of the ions to the primary adsorption of which the surface owes its charge. When the oppositely charged ion is acted on by chemical affinity of the surface atoms, reversal is possible independently of its valency. With univalent ions, however, reversal of the charge has seldom been observed except with hydrogen and hydroxyl ions [see Abstract 91 (1923)]. Further, alkali-metal kations can never reverse the charge of colloidal surfaces since they are univalent and their chemical behaviour may be summed up in their tendency to exist as ions. The alkaline-earth metal ions also are not likely to be adsorbed chemically or primarily, and unless the ions adsorbed primarily are univalent, an alkaline-earth metal ion cannot reverse the charge by electrical adsorption.

The experimental work described deals with the influence of a large number of electrolytes on the charge of negative colloids, and with the preparation of positively charged suspensoids which are usually obtained with a negative charge. In no case was reversal obtained with univalent alkali metal kations and bivalent alkaline-earth kations, even although in some cases the concentrations were at their maxima. T. H. P.

1971. *The Physical Laws of Formation of Ozone by Discharge.* **A. Chassy.** (Comptes Rendus, 178. pp. 1484–1485, April 28, 1924.)—When alternating discharges at high potential are passed through a gas, heat is disengaged, and if the gas be oxygen, formation of ozone also takes place. The present investigation compares the quantity of ozone formed with the heat evolved. Experimental details are included. It has been established that whatever be the voltage and frequency, the numerical ratio between the heat evolved and the ozone formed is constant if the experiment be terminated on each occasion at the same ozone concentration, while the ratio itself depends entirely on this concentration. The law, however, is only exact for the same condition of oxygen in each experiment initially. The total electrical energy is thus transformed into two parts corresponding with the thermal and chemical effects. If Q be the heat effect in small calories, and V the volume of oxygen transformed into ozone referred to 0° and 760 mm., then it is found that $V/Q = 7 \cdot 04$, as a result of a large number of experiments at ordinary temperatures, a ratio which is constant whatever may be the voltage, current frequency, or apparatus dimensions. Temperature has no effect on the ratio between 0° and 25°. H. H. Ho.

1972. *The Production of Nitric Oxides and Ozone by High-Voltage Electric Discharges.* **K. B. McEachron.** (Am. Electrochem. Soc., Trans. 44. pp. 185–200; Disc., 200–202, 1923.)—A modified type of Siemens tube is arranged in which the annular space between the two glass tubes is enlarged and is filled with a large number of glass rods extending throughout the length of the discharge tube. A uniform discharge can thus be obtained without the formation of sparks. A further type consists of a porcelain tube with an aluminium tube on the inside and a second one on the outside. The space between the porcelain and the aluminium tubes is filled with long glass rods. With a tube of this type of 14·4 cm. outside diameter and 152 cm. length, 30-cycle a.c. at a voltage of 47–60 kv. is applied, and a mixed discharge is obtained consisting of corona with a large number of sparks which decrease in number and length with decreasing pressure. In measurements with air, it is found that increase of current flowing in the discharge increases the yield of both ozone and nitric acid up to a certain maximum beyond which further increase in the current decreases the yield. A considerable decrease in pressure is observed, which is greater than can be accounted for by the products obtained. The presence of traces of products of previous runs made in small tubes of the Siemens type modify the character of the discharge and decrease the absorbable products. With increase of pressure the yield of ozone increases until a pressure nearly atmospheric is reached. At higher pressures the yields in general decrease. With increasing pressures, within the limits investigated (900 mm.), the yield of nitric acid increases with tubes in which sparking occurs, and decreases in tubes, like the rod tubes, in which sparking does not occur. Increase in rate of air flow will in general increase the yields of nitric acid up to a certain maximum, the critical air-flow rate being dependent upon the tube used. Increased air rates give increased yield of ozone which tend to become constant at higher rates. Sparks passing through air cause a pressure increase much too rapid to be a heat effect. With an enclosed volume of air a pressure decrease due to ionisation occurs at the instant the power is disconnected. In air the corona discharge favours the production of ozone, while sparks tend to produce oxides of nitrogen. A combination of sparks and corona produces the higher oxides of nitrogen. J. N. P.

1973. *Electrolytic Crystallisation of Lead.* **V. Kohlschütter** and **F. Uebersax.** (Zeits. Elektrochem. 30. pp. 72–83, Feb., 1924.)—The results of a number of observations on the forms of growth of lead separated by electrolysis from its solutions under various conditions; the following conclusions are drawn [see Günther-Schulze, Abstract No. 1933 (1922)]. The separately-growing masses of lead crystals may vary considerably in their external appearance, even when the conditions prevailing during their formation differ only slightly. The following characteristics are, however, observed: (1) The formation of a form type is determined reproducibly by the current density and by the nature and concentration of the electrolyte, and (2) its peculiarity lies not in a difference in the vectorial growth, but in the fashion in which smaller individuals are superposed. Thus, the accidental needle- or sword- or leaf-shaped forms which the separating material assumes are not distorted single crystals with preponderating development in certain crystallographic directions, but aggregation forms. The effects of various factors on some of these aggregation forms are described. T. H. P.

1974. *Ultramicroscopic Observations of the Electrode. Part I.* **V. Kohlschütter.** (Zeits. Elektrochem. 30. pp. 164–175, April, 1924.)—In order to investigate the exact mechanism of the deposition of a metal at the kathode, ultramicroscopic examination is found to give interesting results. The observations of Kossonogow [Abstract 476 (1910)] are confirmed and extended with copper electrodes in dilute copper sulphate, and silver in dilute silver nitrate. In the former case, beautiful effects are obtained; a blue zone due to colloidal copper hydrate and a golden colour due to ultramicroscopic bubbles of hydrogen are the most prominent. A detailed examination of "black copper" and "black silver" is described, and it is concluded that the nature of these products depends upon the "dispersion" of gas in the metal. Electrodes of copper in water alone and also silver in water alone are examined. The important part played by the gases evolved is emphasized, with especial reference to its influence on overvoltage and the adsorption of hydrogen by metals. It is considered that the deposition or solution of a metal electrode is much more complicated than is generally supposed, and further microscopical and ultramicroscopical examination is necessary before any general conclusion can be reached. B. W. C.

1975. *The Dissolution of Lead in Caustic Alkali by Means of Sinusoidal Alternating Currents.* **F. Jirsa** and **J. Fabinger.** (Zeits. Phys. Chem. 109. 3–4. pp. 260–274, 1924.)—In continuation of the researches of Elbs, Grube and Jirsa [Abstracts 2356 (1922), 1345 and 1506 (1921)] the authors experiment with electrodes (cylinders or plates) of pure lead in caustic soda in glass vessels provided with a filter and a tap at the bottom so that the amount of lead dissolved can be determined. Temperatures are kept constant; working in a hydrogen atmosphere is not attempted. The lead, it is found, passes into solution as a divalent element, but not quantitatively, even when the periodicity (range from 29 to 307) is low. The low yield is not due to an anodic passivity and the formation of an oxide film on the lead. The $Pb^{\cdot\cdot}$ ions from the lead react with either $3OH'$, yielding $HPbO_2'$, or with $4OH'$, yielding PbO_2''; the former reaction is the more rapid. In concentrated solutions PbO_2'' is chiefly formed, and less lead is, therefore, dissolved than in diluted solutions. Potential and oscillograph measurements show that there is no phase lag during the electrolysis and neither anodic nor kathodic polarisation, but true a.c. polarisation. Yet there is a certain asymmetry in the curves when a third auxiliary electrode is inserted between the two electrodes, because there may be a direct current from the polarised over to the intermediate electrode. H. B.

1976. *Periodic Phenomena in the Electrolysis of Chromic Acid.* **J. E. Liebreich.** (Zeits. Elektrochem. 30. pp. 186–187, April, 1924.)—The observations and criticism of A. Kleffner [see Abstract 699 (1924)] are discussed in conjunction with previous work of the author on the influence of sulphuric acid on the phenomena studied, and are considered to favour the author's theory of special chemical reactions at the kathode, instead of the passivity theory. It is also concluded that the observations of **K. Oyabu** do not contradict this theory. B. W. C.